ARROVO SECH

SCIENTIFIC AMERICAN SUPPLEMENT

Copyright 1917 by Munn & Co., Inc.

VOLUME LXXXIV] NUMBER 2182]

* NEW YORK, OCTOBER 27, 1917 *

[10 CENTS A COPY $5.00 A YEAR

Launching bridge pontoons down a mountain-side

ITALIAN WAR ENGINEERING [See page 261]

The Measurement of High Temperatures*

Considerations Relating to the Selection of a Standard of Comparison

By Henry Le Chatelier, Member of the French Institute

THE measurement of high temperatures occupies a very small domain of general physics; however, its investigation has necessitated the persevering efforts of particularly well equipped workers. There were, in fact, a great many interior avenues from which to clear the underbrush, and many bypaths to be explored.

All the phenomena of nature form unbroken chains with rigid links which it is impossible for us to break. Though our action upon the exterior world is thus limited to the study of its structure and its internal reactions, this study is none the less very profitable for it enables us to penetrate into the midst of phenomena so that we may utilize to our own best interests the forces always acting. It is thus that the mariner enters port by allowing himself to be carried on the rising tide. He would be at embarrassment in trying to modify the rhythm or the amplitude of the flux and reflux of the sea, but he can know its laws and make them serve his needs.

It is precisely this knowledge of the inevitable relations of science which is the object of science. In the present article I propose to demonstrate what the scientific study of a problem consists in, taking as an example the measurement of high temperatures, or rather, I will endeavor to give a perception of it, for to treat the subject in all its details a large volume would be required.[1]

Among the objects of the measurement of temperatures one of the most important is its application to industrial manufactures. This practical requirement has been the point of departure of all the scientific studies of which I here propose to give a resumé. To understand its importance it will suffice to take a glance at our war factories. In all the gun and projectile works the furnaces are provided with pyrometers. Since the beginning of hostilities more than a thousand have certainly been installed. To obtain a good steel it is necessary to temper it at a rigorously determined temperature; an error of 10 degrees would at least suppress all hardening. Tempered at too high a temperature, the projectiles become brittle and may then burst the guns by premature explosion, such accidents being particularly demoralizing for troops.

The industrial importance of the measurement of high temperatures was first put in evidence more than a century ago by Wedgwood, the celebrated Staffordshire potter, inventor of fine china and of ceramic stoneware.

"The larger part of products obtained by the action of fire have their beauty and their merchantable value considerably depreciated by very slight variations in the degree of heat. Moreover, the artists often lose the benefit of their researches by lacking the ability to reproduce the precise degree of heat realized in a first experiment. It is still more difficult for him to profit by the experiments of others by reason of the lack of any means of communicating, even imperfectly, the idea which any of us may form of such degrees of heat."

We are justified in feeling astonished that it has required a century to remedy a need stated with so much precision as in the words above quoted.

Theoretic Difficulty.—The present methods of measuring high temperatures dates from my own researches (1886) upon optical and thermo-electric pyrometers. Pouillet, Becquerel, Sainte-Claire Deville and Violle had previously given a few isolated measurements, but of doubtful precision and obtained by methods too complicated to be capable of generalization. This problem was long obscured by a theoretic difficulty. Not all magnitudes are, properly speaking, *measurable*. The violence of a tempest cannot be estimated numerically. It is a complex ensemble whose effects depend at once upon the speed of air translation, upon its whirling motion, and on the height and frequence of stationary waves and ground surges.

We measure, on the other hand, a length, a mass, a quantity of heat. To do this we choose arbitrarily a body intended to serve as a term of comparison and called a *unit*. This may be, for example, a body one centimeter long with a mass of one gram. We then try to find out how many times it is necessary to juxtapose this unit in order to constitute a system equivalent to the body which is to be measured. This number gives the measure of the magnitude being studied. By comparison of all measureable magnitudes we easily recognize that they obey the two following laws:

Law of equivalence.—Two bodies, equivalent to a third with respect to a certain property, will also be equivalent to any other body of comparison. Two lengths superposable upon the same division of a meter made of iron will be the same on a wooden meter.

Law of Additivity.—By the juxtaposition of a certain number of identical bodies it is possible to obtain a system possessing the property under study in a higher degree than any isolated body. The combination of several bodies each weighing one gram weighs more than any single one of them.

Comparison.—Magnitudes not subject to these two laws are not measureable. And the same thing holds if they are subject to only one of them. By the juxtaposition of two bodies having the same temperature we cannot obtain a still hotter body; the law of additivity does not hold good, hence temperature is not a measurable magnitude. However, thanks to the law of equivalence, we can compare it. It is this comparison which is very improperly called the measurement of temperatures.

For this comparison we choose arbitrarily a thermometric body, one of the properties of this body varying with the temperature, and measurable. We always fix arbitrarily the unit of measurement and the origin of the graduation, which is called the zero of temperatures. In all comparisons, therefore, four arbitrary conventions are necessary; for measurements a single one is enough, the choice of the unit. There is no necessary relation between the different scales of comparison of a given phenomenon; in measurements, on the contrary, the numerical values vary strictly in inverse ratio with the magnitude of the units. When measured in meters, lengths are only one-hundredth as much as when measured in centimeters. As thermometric bodies alcohol, mercury, air, platinum, iron, etc., have been employed. Properties measured have been volume, pressure, electrical resistance, etc. The choice of units and of the zero point has been no less variable. It is easy to imagine the confusion in which this has resulted. Note, for example, the different determinations that have been made with reference to the baking of porcelain.

Wedgwood. Contraction of clay	140°
Regnault. Heat of melting iron	1800°
Lauth. Water circulation pyrometer	18.4°
La Chatelier. Normal air pyrometer	1375°

Normal Scale.—At present authorities are agreed upon the employment of a single scale of comparison of temperatures, to which are related, by means of appropriate comparisons, observations made in reality by quite different experimental processes. More exactly, we accept also three more normal scales, but which are so closely approximate that in practise they may be used indifferently.

The most satisfactory from the theoretic point of view, that of the future, is the thermodynamic scale deduced from the principle of Carnot. It defines temperatures by the relation of quantities of heat exchanged in reversible manner between the sources compared. This relation, independent of the nature of the body serving for the transport of the heat, dispenses with all arbitrary conventions as to the nature of the thermometric body, and as to the choice of the property made use of. The number of arbitrary conventions is thus reduced from four to two. Herein lies the great merit of this mode of comparison of temperature. On the other hand, it has the great inconvenience of not permitting any material conclusion which may serve for the direct estimation of temperatures. We determine solely by calculation the variations between this fictitious scale and the scales that have been definitely determined.

The normal thermometer of the International Bureau of Weights and Measures is a gas thermometer in which a mass of hydrogen has been enclosed in an envelop of invariable dimensions, at the temperature of melting ice and under a pressure of one meter of mercury. Temperature is defined by the changes of pressure in this mass maintained at a constant volume. For high temperatures a nitrogen pyrometer (synonymous with thermometer) is employed, or more simply, one of air, functioning at a constant pressure. Below is a comparison of these 3 scales:

Thermodynamic scale..	—100.°	50.°	500.°	1000.°
Normal thermometer	—100.005°	50.0004°	499.985°	999.354°
Air pyrometer .	—100.314°	50.0186°	499.460°	998.540°

Experimental Difficulties.—The direct employment of the air pyrometer for current comparisons of temperatures is practically non-realizable. One encounters almost insurmountable experimental difficulties. At the present time we possess hardly a dozen good evaluations of temperatures made by this method, and each of these has required weeks, months, one might even say years, of labor, if one takes into account the preparatory studies necessitated for putting the process into operation.

First employed by Pouillet, then by Becquerel, this pyrometer was first constructed of platinum. Later, Saint-Claire Deville, after having established the porosity of platinum to hydrogen, recommended the use of porcelain. This was not a progressive step, for porcelain proved itself to be even more permeable to water vapor than platinum to hydrogen. Finally platinum was returned to, but with the use of electrically heated furnaces so as to avoid all possibility of the production of hydrogen.

This method permits a special cause of error due to the dead space which necessarily exists in tubes of varying temperature that connect the gas reservoir with the measuring apparatus. The relative importance of this small volume may be reduced by increasing the dimensions of the reservoir. With a volume of 500 c. c. the error would be negligible. But it is impossible to find in a laboratory furnace so large a space at a uniform temperature. It can indeed be obtained in industrial furnaces, but then the thickness of the walls and the elevated temperature in the vicinity of the furnaces render precise operations almost impossible. A volume of 50 c. c. was finally decided upon. Under these conditions highly skilled experimenters consider themselves able to recognize temperatures of about 1,000° within 1° and those of 1,500° within about 5°. However, the variations between equally skilful observers exceed these figures.

Fixed Points.—The difficulty in the use of the air pyrometer prevents us from attempting to employ the ordinary pyrometers for current graduation. We can evade this difficulty, as I have proposed to do, by graduating pyrometers by means of certain fixed points of fusion and of ebullition marked once for all with reference to the normal pyrometer. The determination of these fixed points has been the object of prolonged researches many times repeated before yielding satisfactory results. These measurements constitute the dozen exact determinations of temperatures previously alluded to. They are due principally to Messrs. Holborn, Callendar and Burgess. Below is the list of fixed points at present accepted:

Phenomena.	Substances.	Temperature.	Uncertainty.
Boiling Point	Water	100.°	...
" "	Naphthaline	218.°	0.2°
" "	Sulphur	444.7°	0.5°
Melting Point	Lead	327.4°	0.3°
" "	Zinc	419.4°	0.5°
" "	Aluminum	658.°	1.°
" "	Sodium chloride	800.°	2.°
" "	Gold	1063.°	3.°
" "	SiO^2Li^2O	1202.°	10.°
" "	Nickel	1450.°	15.°

It has not been possible to make measurements with the air pyrometer above 1,500°, but by extrapolation of other scales with temperatures graduated with reference to the preceding fixed points the following evaluations have been made:

Platinum	1755	20°
Electric arc	3500	150
Sun	6000	500

Choice of Pyrometric Methods.—By reason of the difficulties involved in the use of the air pyrometer, for ordinary measurements use is always made of different processes of graduation whose correspondence with the normal scale is established by the intermediary of fixed points. The number of possible pyrometric methods is limitless, for any property whatever of any body whatever may constitute a scale of comparison. In fact, at

* From *La Nature*.

[1] H. Le Chatelier and G. K. Burgess. *The Measurement of High Temperatures.*

least a hundred pyrometers have already been tried. Very few have given satisfaction, and not one is irreproachable.

The points of view which may be considered in choosing one method or another are multiple. The physical property utilized for the datum should be easily measurable. The expansion of solid bodies, for example, only one-hundredth as great as that of gases, would be less advantageous to employ.

But the physical properties of bodies always depend on many other factors besides temperature. For an exact comparison of temperature, therefore, it is necessary either to carefully calculate the disturbing influence of these parasitic factors (we proceed thus with a gas pyrometer by taking into account the calculated influence of variations of atmospheric pressure), or else, more simply, keep all factors outside of temperature invariable. In the earliest pyrometer, that of Wedgwood, which evaluates temperature according to the contraction of small cylinders of clay, this contraction depends also on the chemical nature of the clay, the size of its grain, the proportion of water used in tempering, the pressure in moulding. Since it was never possible to standardize all these conditions this pyrometer has long been abandoned.

In the second place it is necessary to take account of the conditions relating to the heated substance which it is desired to study. A too elevated temperature or the presence of reducing gases in the smoke, for example, would make the use of platinum inadvisable.

Finally, the skill of the operators must be taken into consideration. An apparatus excellent in a laboratory could not be confided to a workman.

Usual Pyrometers.—There are at present six pyrometric methods in use both in scientific laboratories and in manufacturing plants. Let us state briefly their characteristics.

The normal air pyrometer consists of a platinum or porcelain reservoir enclosing air or nitrogen. It serves exclusively for the determination of fixed points.

The electric resistance pyrometer of Siemens-Callendar consists of a platinum wire spiral enclosed in an air-tight platinum or porcelain tube. Slightly less delicate, and of much smaller volume than the gas pyrometer, it is at present the most precise, practical device which we possess for the determination of temperatures between 500° and 1,500°. Its use is limited to laboratories, for its manipulation can be entrusted only to scientists trained in measurements of precision.

The Becquerel-Le Chatelier thermoelectric pyrometer is, of all the apparatus we possess, the simplest and the smallest in volume; it is also the one most employed in laboratories and in factories. It adapts itself easily to photographic registration.

The Le Chatelier-Wanner optical pyrometer utilizes the measure of the intensity of the monochromatic red radiation transmitted through glass to copper. It is suitable for the estimation all temperatures above 1,000°. Its indications are influenced by the emissive power of incandescent bodies.

The Féry calorific radiation pyrometer has the same field of application. Its use is very widespread in manufacturing plants because it is easier to teach the workmen to read the indications written on a dial than to demand a photometric measurement from them. But this apparatus has not yet been subjected, from the point of view of precision, to so exact a control as have the preceding.

The Seger indicators, widely employed in the ceramic industry, make use of the fusibility of mixtures of kaolin and various fluxes.

Thermo-electric Pyrometer.—Let us take as an example the study of the thermo-electric pyrometer. How is it that this method so generally employed today required 50 years for its adoption. Proposed in 1830 by Henri Becquerel, it was not actually employed until after my researches in 1886. Henri and Edmond Becquerel, Pouillet and Regnault sought to compare the indications of thermo-electric couples with those of the air pyrometer, but without arriving at any result. Regnault even drew the conclusion from his experiments that the method was worthless. The exactitude of Becquerel's measures was strongly contested by Saint-Claire Deville. As for those of Regnault their inexactness is glaringly obvious. He had neglected to take account of the variations in resistance of the electric circuit. To remove the difficulties of graduation I proposed to relate the indications of the couples to the fixed points of fusion and of ebullition of some very pure substances. This sufficed to place the graduation of temperatures on a firm basis.

Moreover, the old galvanometers with movable magnets exhibited so great an instability that reading them was always difficult, and even impossible when the ground was subject to tremor, as is always the case in factories. The employment of the galvanometer with a movable coil removed this difficulty. Finally, by giving to the coils a resistance of 200 ohms to cancel the influence of changes of resistance in the couples, and by employing suspension wires of hammer-hardened German silver in place of annealed silver we can obtain entirely regular indications.

A final difficulty to be removed concerns the couples. It had not been perceived that certain metallic wires heated at one end gave rise to induced electro-motor forces. The rhodium platinum-platinum couple is free from this defect, or more exactly, suffers from it to a very slight extent.

Graduation of Couples.—Frequent repetition of the graduation of couples is indispensable. These undergo alteration in the course of service; moreover the sensibility of galvanometers varies with time, either because of the loss of magnetism on the part of the permanent magnets, or because of charges in the verticality of the apparatus. The movable coils, always rather heavy, rarely have their center of gravity exactly on the line of the points of suspension. From this there results a disturbing couple tending to modify the indications of the galvanometer.

The relation between the electromotor force of a couple and the difference of temperature of its two junctions is expressed by the following formula:

$$\text{Log } E = a \text{ Log } T + b.$$

Two fixed points, therefore, are sufficient for a graduation. It is the custom to take three, one of them serving as a control. By preference they are selected in the interval of temperature upon which the measurements are to bear.

For the ebullition points of water, of naphthaline, and of sulphur, we employ test tubes surrounded with plaster in the central half of their length, and place the couple in the midst of this area. The vapor condensed in the free upper part of the tube constantly flows back along the insulated region where the couple is placed.

For the fusion points of metals—aluminum, gold, palladium—we surround the junction of the couple with a few windings of wire 0.5 millimeters in diameter and place it in a medium where the heating will be very regular. At the moment of fusion a slight arresting of the elevation of temperature, due to the absorption of latent heat, indicates the fusion.

For sodium chloride, we plunge the couple in a small crucible filled with the melted salts, and allow it to cool. The temperature remains stationary for a very long time during the cooling process.

Causes of Error.—It would seem that when the study of the method has been finished, and the disturbing factors carefully determined, the measurements would be quite exact. But it happens too often in these measurements, as in all scientific research that one encounters unlooked for errors, which are at times very difficult to discern. Unsuspected factors suddenly begin to operate and upset all expectations. Here are a few typical examples:

The most frequent accident is the loosening of the wires of a couple when they have been merely twisted instead of soldered together, or even rupture in case they have been heated in a reducing atmosphere. If there is an entire cessation of contact no harm is done, since the operator is warned; often, however, the separated wires continue to touch each other, allowing the current to pass, but with reduced intensity because of the supplementary resistances at the contact, and the measurements are falsified with no warning to the operator.

A difficulty which was very frequent at first, but which has now disappeared because of the better construction of galvanometers, arose from the rubbing of shreds of silk, which were poorly varnished, against the central core of soft iron. This disturbance was intermitten, the silk fibers lying down or standing up, according to the hygrometric condition of the air.

An analogous cause of error, and one very frequent in factories, proceeds from the settling upon the magnetic core of iron of particles of metallic iron. These rise and stand perpendicularly to the coil and retard it very slightly. This cause of error is even more difficult to recognize than the preceding.

Finally, in laboratory experiments, when the wires of a couple are immersed for a very short length in the hot substance being studied, the calorific conductibility of the wires cools the solder and falsifies the indications.

Photographic Registration.—One of the great advantages of the thermo-electric method is that it readily lends itself to photographic registration. It is sufficient to cause a sheaf of rays of light emanating from a very narrow slit or hole to fall directly upon a mirror, borne by the galvanometer, which reflects it to make impression on a photographic plate. This method has often been taken advantage of for the study of the critical points of steels, which, since the investigations of Osmond, have played such a great rôle in the development of scientific metallurgy.

I made my first registrations by receiving upon a fixed plate a luminous ray sent out at fixed intervals, *e. g.*, every second. In spite of its advantages, this method is not widespread, and it is preferred to receive the impression upon a movable plate, having a movement of uniform translation so as to obtain directly a curve giving the time in abscissae and the temperature in ordinates.

M. Saladin has invented a very ingenious photographic device which permits the registration of curves of any nature upon the fixed plate by means of two mirrors, both of which are animated by a rotation movement around a vertical axis, governed, for example, by two parallel galvanometers. For this purpose it is sufficient to intercalate between the two movable mirrors a fixed mirror inclined at 45° upon the horizontal plane. The luminous ray reflected by the first mirror and thus animated by a horizontal movement, is displaced vertically after reflection upon the mirror fixed at 45°. From there it is reflected upon the second mirror, which communicates to it a second and final horizontal displacement. Finally the composition of these two perpendicular movements draws a curve upon the fixed photographic plate.

We can thus directly register the curves of electric resistance, of expansion, of electromotive force in function of the temperature.

Conclusion.—In entering into these details I have desired to show what the scientific study of a problem consists in, and, on the other hand, to indicate what scientific instruction ought to be.

Science has for its sole object the study of the mutual and inevitable relations of natural phenomena, *i. e.*, the systematic research of the factors, the estimation of their relative degree of influence upon the object sought, and, finally, the experimental determination of their numerical laws. Science thus comprehended is interesting, not only by reason of the more perfect knowledge it gives us of the world wherein we live, but, also, by the control it permits us to acquire over natural forces to make them of use in our different industries. The essential object of scientific instruction should be to awaken in the minds of students the feeling of the interdependence of phenomena, to stimulate the desire to know the laws that govern them, and, finally, to put at their disposal the methods of work useful in aiding them to acquire by their own efforts the knowledge of these laws in all the circumstances of life in which they may be placed.

In the classic mode of instruction in physics the thermometers most frequently employed are, indeed, described, but this is of small use, for the same information can be easily found in books. The only thing of importance is *the reason* for the arrangements adopted. It is not a question of burdening the memory with such more or less important information; but of imparting a certain intellectual orientation. Herein is a question of capital importance for the revival of industry after the war.

Anomalies Seen in Animals Due to Artificial Selection and Breeding

When we pass from what we find in nature—in the matter of abnormalities and anomalies among animals—to observe what is to be found all over the world, in places where man has bred a great many different kinds of animals to meet the ends of his demands for variety, for food and for gain, we meet with forms on all hands which, as representing departures from the usual and the normal, has nature outdone at every point. Such trade, experiments and exploits have been in vogue as far back as we care to trace them in history.

Some of the best examples of this are to be found in the vegetable world, and one has but to compare many of the vegetables found in our markets to day with the wild stock from whence they were derived by artificial selection, to appreciate what has been accomplished by such means. Some of the so-called "small fruits" furnish us with admirable examples, and as for flowers, their transformations from the wild species has been truly marvelous in hundreds of instances; while such experiments as Luther Burbank has succeeded in, and is successfully making, carries many tasks of the kind to the very limits of their capacity. Seedless melons; spineless cacti, and many similar productions.

Testing War Cripples

Scientific Estimation of Equitable Pensions and Indemnities

One of the serious questions of the day is the establishment of proper indemnities for temporarily or permanently injured soldiers, whether by pension or by insurance. Whatever the form decided upon, an immense amount of adjustment will be required to insure a proper ratio between the degree of damage sustained and the proffered compensation. Similar problems in France are being met with less delay and more equity than was formerly possible by reason of the application of scientific methods of determining the exact degree of physical disability in any given case, aside from the victim's own impressions, which may or may not be colored by memories of past sufferings or hopes of future ease. Our own authorities may well profit by French experience along these lines, and we are accordingly glad to quote from a late number of *La Nature* (Paris) a *résumé* of the subject as follows:

In the matter of workmen's accidents sufficiently recent legislation has taken account of modern medical and surgical knowledge and established a series of measurements adjudged satisfactorily by those concerned: Workmen, employers and insurance companies. In the matter of military injuries, this was not the case when the war broke out. The question was regulated by the law of 1831, excellent for that period, but now a trifle stale. In these laws injuries contracted in the service of the State are divided into two groups, those diminishing capability by more than 40 per cent., and, therefore, entitling the victim to retirement and a pension, and those less serious, justifying merely a "reforme" (invalidism); No. 1 carrying a renewable indemnity. The infirmities justifying a pension are divided into six classes, according to their importance and the degree of incapacity entailed. This classification has been rendered behind the times by medical and surgical progress. For example, the old law regarded as equally grave the loss of the use of a limb, ankylosis of the knee, the loss of the great toe, or of two other toes, amputation of the thigh was considered more serious than hemiplegia accompanied by insanity, etc.

Up to 1914 the governors of the Health Department of the Army of the Interior continued to prescribe the application of these laws, scarcely modifying even the nomenclature of the *réforme* cases. But since the beginning of the present war account has been taken of the serious imperfections of the regulations in force, and the errors and injustices they entailed, sometimes at the expense of the wounded man, sometimes at the expense of the Government. Physicians desiring to avoid manifest absurdities were obliged to violate existing rules and make personal decisions, which varied fatally in different pension centers, thus creating unjust inequalities in similar cases.

On March 24, 1915, a Government decree modernized and made definite the instructions for medical estimation of incapacities, and the scale of gravity of wounds was modified and brought more into harmony with modern knowledge.

To the regulation commissions of *réforme*, often not very competent, a ministerial circular of March 15, 1916, added local medicolegal appraisal commissions, composed of specialists, who are charged with supervising the establishment of *réforme* reports, with ensuring uniformity and precision in estimates of incapacity and with connecting the *réforme* commissions with a medical consulting commission created in December, 1914, and definitely organized by the decree of March 5, 1916. This last commission verifies the *dossiers* of pensions or indemnities, supervises the decisions of the *réforme* commissions, and suggests their modification if need be; it keeps the Ministry informed upon all questions and advises it as to the proper course.

Fig. 1.—Apparatus for measuring the movements of articulations: at top left the apparatus of Camus and Faidherbe for the pronation and supination of the hand; at top right Dupont's apparatus for movements of the fingers; below Dupont's apparatus for the large articulations

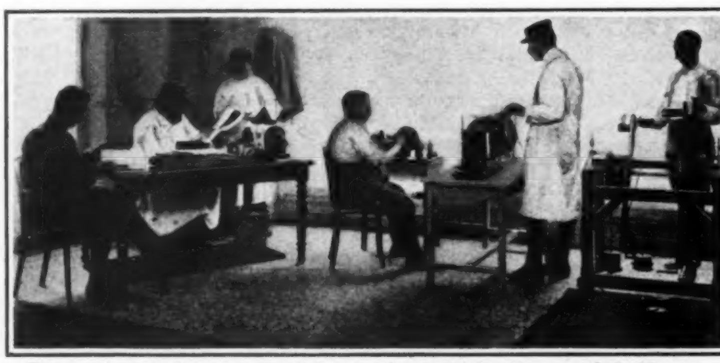


Fig. 2.—Appraisal room at special center for examining the wounded réformes

This consulting commission, by its contact with the local experts, has helped to unify the rate of pensions and indemnities, to correct defects and errors of regulations and of experts, and to establish a valuation of infirmities equitable at once for the Government and for those concerned.

The counter-appraisals with which it is charged being often delicate and difficult, Chief Surgeon Jean Camus proposed the organization of a special center for the examination and complimentary treatment of *réformés* (*i. e.*, men who have been invalided), which should be at the same time a research laboratory for the investigation of the best methods of examination, unification of measures, etc.

The aid obtained from the Association of Insurance Companies, themselves strongly interested in the establishment of exact methods of appraising incapacities, that of various other individuals or societies, and the initiative of the *Service de Santé*, made possible the opening of this center at Paris, about a year ago. Since that date nearly 500 *dossiers* have been appraised there, with the utmost precision, resulting sometimes in the incerase, sometimes in the diminution, of rates of indemnification, so as to safeguard the interests of all.

The processes of examination employed at this center are largely of recent invention; many have been, after careful "control" experiment, recommended to local appraisers and made use of by them. Thus step by step, a truly objective science of appraisal of incapacities is being organized, infinitely surer and more rational than the opinion, no matter how experienced and how conscientious, of a physician or of a commission judging solely after a clinical examination.

In this manner, too, a solution is being prepared for one of the most delicate questions of the post-war period, that of the equitable adjustment of indemnities to the numerous victims of the present conflict.

We are able to state today that France possesses the means of avoiding errors and injustice in the reparation of the ills due to wounds and disease resulting from this war.

This special center of examination of invalided wounded men (*réforme*), makes use of a series of measurements relating, some to the anatomical condition, others to the physiological function of portions of the body suffering from lesions.

From the anatomical point of view the observer notes the extent, aspect and adherences of cicatrices and the deformities occasioned by them. Photography and radiography are made use of to record the condition of a wound at any given time.

A whole series of apparatus is employed to measure the functional condition of muscles and articulations. These are goniometers with two jointed legs along which metric tapes can slide. The angle formed by the two legs is read from a dial; the tape permits the measurement of the circumference of a limb at a given height above the joint. Apparatus with long legs are used for the shoulder, hip, elbow or knee; smaller ones for wrist, fingers, foot; others, still, for the rotation of the wrist (fig. 1).

In order to learn the functional condition of the muscles of a wounded limb the physician measures and registers the strength, rapidity and amplitude of movements, and the speed with which fatigue is induced. Dr. Camus has invented two dynamo-ergographs for these registrations, one for the large movements of legs and arms, the others for the less ample move-

Fig. 4.—Camus apparatus for registering vaso-motor troubles

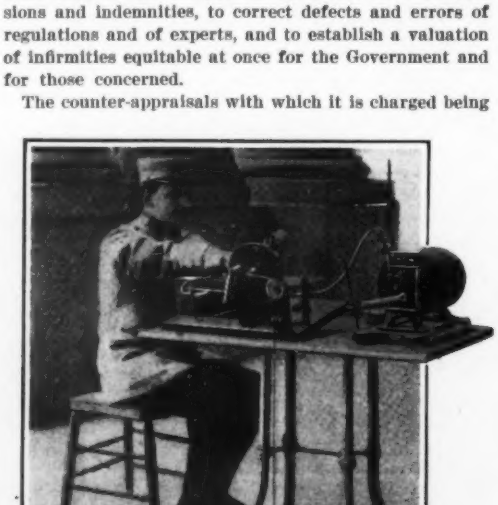


Fig. 3.—Dr. Camus's special dynamo-ergograph for the study of small movements

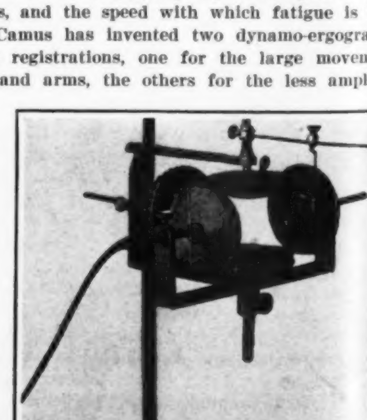


Fig. 5.—Camus apparatus for registering tremor

ments of the hands, wrists fingers (figs. 2 and 3).

Both of these consist of a lever fixed upon a pulley upon which is wound a cord or wire carrying a weight which can be varied at will. The movements are inscribed by the proportional displacements of a stylus on a registering cylinder on which periods of time are marked equally by a metronome and a signal.

In this manner graphs can be obtained representing the speed and amplitude of movements, and the fatigue induced by a given resistance. This tracing can be kept and used to compare the physiological condition of a member or a segment of a member at a given time with that of the same member at another time or of the opposite sound member.

Nerves and muscles are tested by Faradic and galvanic currents to obtain precise data as to their functioning (vide *La Nature*, No. 2197).

Dr. Camus has invented an easily regulated and highly sensitive instrument which records all the details of vaso-motor troubles, which so frequently follow wounds of the nerves (fig. 4). Tremor is likewise registered by apparatus composed of three registering drums oriented in the three directions of space (fig. 5). Psychomotor reactions are also tested by processes which have already been described in these pages apropos of the examining of aviators (*La Nature*, 2223).

These methods enable us to substitute for the long descriptions by experts, always incomplete and inexact no matter how carefully edited, documents which are absolutely complete and objective photographs, tables of figures, graphs, which allow no latitude of interpretation. These methods are now applied to all the counter-appraisals made by the Consulting Medical Commission, their use is being rapidly extended among the local centers; the Committee of Insurance Companies is planning to employ them in all questions arising from labor accidents. They furnish an absolute guarantee of equity both for the cripples of war and for the taxpayers who will have to pay the too numerous pensions of which the latter is the cause.

Italian War Engineering

THE great conflict has been called an engineers' war because of the unprecedented extent to which engineering problems, both in the mechanical and civil branches, have entered into every phase of the operations; the elaborate trench work, the building of roads and railways, of guns, rifles and machine guns in endless variety, the development of motor transportation and the wonderful evolution of aircraft; and everything has been done on a scale and at a speed that almost surpasses comprehension. But while the achievements in France and Belgium are wonderful, they become simple matters when compared with the problems that have confronted the Italians in their struggles among the crags and lofty peaks of the mountainous region where their operations have been, and are still being carried on. Everything that has been done on the Western front has been accomplished by Italy in the South, and with the additional complication, rocky gorges and what were heretofore considered inaccessible mountains, and practically with her own resources without any outside assistance. Indeed, the story of Italy's operations will be the most remarkable chapter in history.

One of the feats of the Italian engineers, which has received but scant attention in this country, was the passage of the Isonzo river. All of the points where it was supposed that a passage of the river could be effected were strongly guarded by the Austrians, but Italian ingenuity and skill was equal to the occasion. A point was selected where an advantageous coup could be effected on the Austrian side of the river, if troops could be transferred across the stream. On the Italian side the shores were so rough and precipitous as to preclude any bridging operations. In some way not explained the Italians dragged a number of large pontoons, together with the necessary timbers, over the mountains behind, and while the Italian batteries distracted the attention of the enemy by a fierce and protracted bombardment, and obscured the operations with smoke, the pontoons were lowered down the cliffs, and a bridge was quickly thrown over the stream, a strong body of troops crossed, and the enemy was completely surprised by a successful flank movement that resulted in the loss to them of much valuable ground and some strong positions.

The illustration on the front page of this issue, taken from L'Illustrazione Italiana, shows the last stage in the operation of lowering a pontoon down the mountain side, and the picture on this page gives an idea of the character of a bridge of this kind.

Making and Melting High Temperature Alloys

THERE are two things worth attention in most places where there are facilities for making and casting them, one being what are called "Mitis" iron, which, if properly made, is a homogenous form of wrought iron which, without annealing, can be bent or forged either hot or cold, and very well takes the place of mild steel—it can be casehardened—and the other is a form of bronze containing anywhere up to 60 per cent. of iron, but probably most usefully about 20 per cent., and which can be rolled and otherwise worked while it is practically incorrodible. Both of these to be successful must be made from carbon free iron, and both must be quickly melted in closed crucibles to prevent the absorption of carbon in a gaseous state so far as possible; the successful results in each case being conditional on the absence of carbon, phosphorous, and sulphur.

An Italian Military Pontoon Bridge across a mountain stream

Only the best Swedish iron can be used in the work, and in the case of the iron only a small proportion of the scrap arising from the casting processes can be utilized a second time, for which reason there must be an outlet for the scrap metal for cupola use. The bronze can, of course, be remelted if properly made with as pure commercial metals as are obtainable.

In the case of the iron castings there is little or no saving in cost over ordinary annealed malleable castings, while it is possible that even a higher cost may occur, the chief advantage being that time is saved, the castings being ready as soon as made; this not being the case with the ordinary annealed malleable iron castings, which often take a month or more for delivery. With the bronze the metal can be produced from 6½d. per lb. or less, ready for pouring into the moulds, while machined castings are practically incorrodible when exposed to the air. There is nothing to prevent anyone making these things provided they have the appliances, and it is just here that the trouble comes in, and to understand this the processes of manufacture have first to be considered.

In making iron castings you have to melt the iron in roughly 75 lb. lots (net), and get it fluid in about 2 to 2½ hours; the crucibles are then opened and aluminum up to 0.5 per cent. added in the form of ferro-aluminum with an Al. content of from 8 per cent. to 10 per cent., the actual amount being determined in the laboratory according to the iron used. The melting point of the iron will be somewhere between 1500° and 1600° Cent., or, say, from 2700° to 2900° Fah., and it takes about 1⅛ cwt. of really good furnace coke to melt each 1 cwt. of iron in a good furnace.

In making the bronze the iron has to be melted as for the iron castings, and to this is added the copper at a red heat, and with a melting point of about 1050° Cent. or 1925° Fah. This being followed by the tin or zinc, both of which melt at a low temperature, and if added in as hot a state as possible by the reactions caused no additional fire heat is necessary. The alloy when made melts at somewhere between 1050° and 1200° Cent., according to content, or, say, from 1900° to 2100° Fah., which is about the range for cast iron.

As there must be the greatest freedom from carbon possible, clay or other crucibles free from carbon must be used, and as such crucibles can rarely be used again after being cooled down, as many successive melts as possible must be secured for the sake of economy, this meaning in practice that either single or multiple pot furnaces must be provided with forced draught to ensure that the carbon of the fuel is reduced to the highest state of combustion—carbonic acid—and it also means that the heat must, as far as possible, be held in the furnaces and not sent up the flues. Of course, crucibles in this kind of work are stood on stands to keep them steady and in position, thus assisting in the arrangement of the blast, and as this should not, as a rule, exceed 3" on the water-gauge, there should not be excessive fusing of the walls of the furnaces, provided dry, or possibly preheated, air is sent in. To secure high rates of combustion large volumes of air at just sufficient pressure to cause it to penetrate to all parts of the fuel are necessary, while it is also desirable that the fuel be broken to a moderate size to expose as much surface as possible. The physical structure of the coke has much to do with both the volume and pressure of the air used, and can only be determined by actual trial at the furnaces being operated.

Various forms of furnaces are used, but in every case the object aimed at should be that of concentrating the heat on the crucible or crucibles which the particular form of furnace is made to contain, the mere burning of fuel not always being equivalent to heating power. The writer has his own ideas in regard to furnace construction for this purpose, as it is possible to keep the walls comparatively cool while preheating the air; but whether it is worth while to make the necessary drawings and written explanations is quite an open question. In any case, there are many furnaces already working well in various places for both single crucibles and for three and four crucibles in each fire, for which reason there should be no difficulty in selecting a suitable form. Only the best workmanship in erecting and the best material will stand the intense heat for any time, which in general practice confines the choice very largely to fireclay bricks, which in the best forms will stand up to approximately 1700° Cent. with a fair durability, but chromite bricks will stand up to 2000° Cent., and magnesia bricks up to 2150° Cent., should it be considered advisable to use these irrespective of cost. As, however, with a well constructed and carefully fired furnace the walls are not the hottest part, a good fireclay brick should stand very well; but all depends on the bricks, in some cases the method of manufacture not being all that can be desired, quite irrespective of the content of the fireclay.

The tools used in connection with furnace work must be well made and of sufficient strength, particular attention being paid to the lifting tongs, which *must* fit the crucibles and grip them right round in two or three places, owing to the fact that crucibles, whether of clay or plumbago, become more or less plastic at really high temperatures, although they do not reach a state of actual fusion. All stirring of the metals should be done with fireclay rods or stirrers, and not with iron, as in the usually adopted manner, because carbon may not be introduced in any way either in a solid or gaseous state.

High temperature and freedom from carbon being necessary, it may well happen that electric furnaces would answer better than fuel furnaces; but at the present time the writer has not heard that trials have been made in this direction, although the matter is certainly worth some amount of investigation where facilities exist.—*The Practical Engineer.*

Theory of Rotation of Spiral Nebulae

THE recent results of Van Maanen at Mount Wilson in demonstrating the rotation of the nebulæ M. 101 and M. 81 appears to confirm the theory of vortices for cosmical systems which has been elaborated by Belot. The exponential equations involved are the same as those he has presented as governing the distances of planets and satellites in our solar system, and the comparison is emphasized as favoring the reality of the theory. —Note in *Sciences Abstracts* on a paper by E. BELOT in *Comptes Rendus*.

The Scientific Detection of Crime

By Matthew J. Eder, Editor The National Police Journal

This is a highly scientific age in which we are living. Every move made by the human body and by the things conceived by the human mind have been brought down to such a degree of perfection, by the application of scientific means thereto, as to cause the casual observer thereof to stop in wonderment. Not the least of these methods which have undergone radical changes in recent months are those employed by criminals in the pursuit of their illegitimate profession; and the methods pursued by the police in an endeavor to curtail these activities and clear up the mysteries surrounding the perpetration of crime have accordingly kept apace.

So well does the criminal of to-day cover up his tracks and so far advanced are his tactics that the detection of crime and the conviction of criminals now frequently depends on a hair. The problem confronting the police, then, is to find the hair. But before they can find it they must know how and where to search for it.

We are all aware, through having closely followed the evidence produced at important murder trials, chronicled in the newspapers, that the examination of the hands and fingers has long been recognized by the police authorities as an aid in establishing the identity of individuals and connecting them with infringements of the law. The process with which we are familiar is the examination of the inner surface of the finger for those little lines which give us the finger prints, but few of us have ever thought that by going clear to the tips of the fingers and under the finger nails, any evidence of wrong-doing could be revealed. This is a region of the hands which, until a short time ago, had been much neglected by our officials. Yet here is the place where the missing hair is frequently found, with the aid of a microscope, and it is surprising how many other things besides hair find their way under the finger nails. The stories that such substances tell are often remarkable.

The value of examining finger nail deposits becomes evident immediately when we recognize that everyone carries away on his finger nails a sample of all of the material he handles. Thus the handling of a piece of cloth will result in the person carrying away with him a few fibers of which the cloth was composed. Of course, much such material is promptly lost, but if the fibers find their way under the nails, it is possible to discover them there after some time, maybe a week later. And if the cloth had been red, you will find red fibers; and if the cloth had been green, you will find green fibers. Not only that, but if it were woolen cloth the appearance of the fibers would be quite characteristic and different from fibers derived from cotton or linen cloth.

As can be imagined, the number of substances which occasionally find their way under our nails is large and their characters quite diverse.

LEGITIMATE AND ILLEGITIMATE DEPOSITS

In order to get a proper idea of their possible nature, it is necessary for the police to classify the accumulations, and they are accordingly subdivided into what are called Legitimate, or those we are entitled to have under our nails, and the foreign or Illegitimate. In the first place under the Legitimate, we have those which are derived from our own bodies. These things mostly come from scratching, which everyone does more or less each day. The substances so accumulated consists, therefore, of cell derived from the skin and occasional small particles of hair. We also legitimately accumulate fibers from our own clothing.

Sometime ago Dr. Charles E. M. Fischer of Chicago, who has done much to demonstrate the value of examining the finger nail deposits of suspects, made an experiment to show the variety of substance so derived.

After cleansing the nails as thoroughly as possible, he started to dress and at the end of the procedure he found cotton, woolen and silk fibers and a squirrel hair. The clothing consisted of cotton underwear, which contributed cotton fibers, black woolen socks, which contributed some wool. From the shirt no fibers could be identified, neither were there any from the collar. Both of these had been thoroughly smoothed by ironing, allowing, while fresh, slight chance for fibers to be lost. The process of starching also interferes with the loss of fibers from the material.

However, in buttoning the neckband of the shirt and in adjusting the collar, the fingers came in contact with the skin and a few cells were so accumulated. From the green tie a silk fiber was found. The brown worsted suit gave a few brown wool fibers. From the grey worsted overcoat a fiber of white wool was present, while the squirrel hair came from fur lined gloves.

DEPOSITS GATHERED UNCONSCIOUSLY

In this experiment, Dr. Fischer asserts, there was no effort made to scratch the surface of the different articles of wear. They were handled only in the usual manner. At another time in repeating the experiment a red cotton fiber was found. This fiber could not be accounted for as coming from any of the wearing apparel. Its origin was finally traced to a red bed quilt.

There are very few persons who do not accumulate material under their finger nails, so that this latest device of the police is certain to prove successful in solving crimes where objects and articles have been handled. It is only those rare individuals who clip their nails down to the point where the nails leave the skin that have no accumulations under their nails. Other people, no matter how much care they may take of their hands, are bound to show some of these accumulations.

Ordinary washing, it has been proved time and again, will not remove the material from under the nails. Scrubbing the nails with a nail brush also has very little effect. Subsequently cleaning with a knife blade or other pointed instrument removes only the gross part, leaving many things behind.

As the finger print and other systems of identification have been put into use by the armies of the warring nations, so the possible value of micro-analysis, as the examination of finger nail deposits is known in police circles, in the examination of spy suspects is now being discussed. This idea suggested itself to Dr. Albert Schneider, of San Francisco, who is generally credited with having been the first one to see the value of finger nail deposits in solving the mysteries of crime, on making microscopical examinations of the nail deposits and personal effects of persons who were traveling or had just completed a journey and those who carried out special errands and missions.

The microscopical findings gave evidence of the following:

1. The character and kind of physical labors performed for periods of three to eight days.
2. Evidence of the kind of clothing worn for three days previous.
3. Fiber derived from legal documents, bank notes, from Pullman car furnishings, etc.
4. Evidence of trade and business engaged in, as farmer, milliner, pharmacist, stenographer, cook, grocer, etc.
5. Evidence of personal habits and peculiarities.

A HYPOTHETICAL CASE

The following hypothetical case will serve to explain the value of this form of microanalysis:

Let us suppose that several men wearing the more or less bedraggled uniforms of a Pomeranian regiment are brought into the headquarters of a German regiment stationed at the Eastern front in Russia. The men claim to have become separated from their respective companies during a night attack. They all speak dialect German, having given the correct passwords and have answered all questions clearly and concisely. One is suspected of being a spy. He is stripped and carefully examined. There is nothing suspicious found in and about the uniform worn. Everything is correct, even to the regulation German underwear and socks.

An assistant takes the finger nail scrapings of both hands. These, with the dirt and mud-bespattered boots and clothing of the suspect, are rushed to the field laboratory. Within two hours the analyst submits his report with an interpretation of the findings. The suspect is brought before the commanding officer who addresses him as follows:

"You are a Russian spy. You are an officer in the Russian army, division so and so. You killed private R. H. of our outposts. You have been hiding among Russian peasants who supplied you with such and such food. Part of the distance you rode a young bay horse, and you also rode an old gray horse. You crossed the forest R at night. You crossed the stream D at a point X and you entered our lines this morning. You will be shot at sunrise."

The possible statements might be based upon the following findings of the microscopical examination of the finger nail deposits and of the stains and smears in and upon the clothing worn:

1. Cloth fiber of the color and quality of the officers' uniform of the Russian army, division so and so.
2. Heat dextrinized rye, pea, and lentil starches of bread prepared by Russian peasants.
3. Cork cells of hazel brush, of oak and soil algae, peculiar to forest R.
4. Epidermal cells and more or less disintegrated red blood corpuscles.
5. Diatoms, desmids and blue green algae peculiar to locality X or stream D.
6. Hair of bay horse not over four years old.
7. Hair of bay horse over twelve years old.

The fact that the spy works under high tension, without opportunity for rest or proper attention to his toilet, adds to the value of the findings of the finger nail deposits. He may make a complete change in wearing apparel and in personal equipment, but the telltale evidence of his real mission and his movements and whereabouts for several days previous remains, as Dr. Schneider has proven, even in spite of repeated careful washings with soap and water and wiping with a clean towel.

It is perhaps unnecessary to point out that efficiency in this line of micro-analysis depends upon a very wide range of experience. Some of the skilled micro-analysts now employed in the critical examination of foods, soils, and textile fabrics, Drs. Schneider and Fischer and other experts believe, would no doubt qualify. The necessary practical experience for doing efficient work along this line could not be attained in less than ten years. Naturally these laboratory workers would not be employed in the examination of spy suspects alone. They would also be qualified to make bacteriological and sanitary examinations and investigations in the war zone.

Photo-inversion

It has been found that the photographs taken at the top of a volcanic cone showed positive pictures instead of negatives, and other photographs taken in the vicinity of the volcano were somewhat different from ordinary negatives, that is, they showed a thick line on the contours of the mountain, of trees, and of their shadows on the surface of water. It was thought at first that the above changes might be attributed to some radio-active substances in the volcanic region. On testing it was found that the lava gave out no radio-active rays. Photographs taken at sulphurous hot-springs show similar changes on the photographic plates. From these facts, it was suggested that a gas such as sulphur dioxide, which is often present in the atmosphere in volcanic regions, might have a certain action on the gelatine silver-bromide of the sensitive film and might cause the reversal. In this view the following experiments were carried out, the result of which shows that the photographic films of gelatine silver-bromide give rise to photo-inversion by the action of SO_2 gas, and may have positive or negative pictures if the concentration of SO_2 gas, the time duration to the exposure to the gas, and the intensity of the incident light satisfy suitable conditions. The concentration of SO_2 gas being constant, the degrees of inversion are different for different times of exposure. The time of exposure being constant, the degrees of inversion are different for different concentrations of SO_2 gas. A positive picture generally appears in a wider range of the intensity of light and of the time of exposure to SO_2 gas, for the weaker concentration of the gas than for the stronger. There exists for photo-inversion the commutative action between the exposures to the gas and to the light. The action of SO_2 gas gradually weakens with time and disappears generally within several hours. Photo-inversion closely resembles solarization in the change of grains in the film.—H. Saegusa *in Proced. Math. Phys. Soc., Tokyo.*

Correspondence

[*The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.*]

New Thermometer Scale

To the Editor of Scientific American Supplement:

In the Scientific American Supplement for October 28, 1916, a thermometer scale was suggested by Prof. Alexander McAdie. This scale was suggested by me long before, as you will see in the Scientific American for November 26, 1887. This scale has several advantages.

I believe that since my suggestion Lord Kelvin suggested a scale in which the space between absolute zero and the freezing point is divided into 100 equal parts instead of 1,000 according to my method. Lord Kelvin's degrees are of enormous length.

I also devised a new barometer scale, see Scientific American, Ap. 20, 89, and a gas scale, see Scientific American Supplement, July 6, 1889.

James Asher.

The Field of Vision*

The Effect of Harnessing Up Indirect Vision

By Dolphus E. Compere, M.D.

Briefly speaking, the eye is a dark chamber with a series of convex refracting surfaces and certain intra-ocular media or watery substances.

The sense of sight consists of three visual perceptions or subsenses, viz., Light sense, color sense and form sense. Light sense is to be able to perceive graduations of the intensity of illumination. Color sense is the power of distinguishing light of different wave lengths. There are three sets of color perceiving elements: those for blue, red and green. These are termed primary colors, all others are compounds of them. Blue has the largest field of color, next comes red, while green has the smallest field. In other words, green excludes more light than any single color known. Form sense, or acuteness of vision, is the faculty the eye possesses of perceiving the shape or form of objects.

The field of vision is divided, first, into central or direct which is to fix the eye on one object and see clearly and distinctly. Second, peripheral or indirect vision, is to see around the one point and see objects not looked at, which are less distinct or a duller sensation. Example: If standing on a hill, we fix the gaze of one eye on some special object on the plain below, the field of vision includes not only that one object but many others even for miles around it. If the fixation object be nearer us, the area taken in by our field of vision will be proportionately diminished in extent. The average normal field of vision, which is the limit of indirect vision, is temporal 90 degrees, nasal 60 degrees, above 60 and below 70 degrees. The nose and eyebrows project into the field of vision and limit it.

The evil effects of the constant strain and excessive demands upon the muscles of accommodation, to exclude this indirect vision, to the extent of preventing it from interfering with the direct vision, are manifested by spasm or cramp, which produces blurred or indistinct vision. After continuing this over-taxing, say for distant objects, the eye uses up part of its accommodative energy, which actually leaves less at disposal for near objects. In extreme cases of high degree accommodative spasm, serious errors might arise if this cramp is overlooked, and often a person cannot maintain a sustained view of an object at any distance without suffering pain in and around the eyes.

Scientifically speaking: Accommodation means adjustment of the eye for various distances on one special field or object. Example: Hold a book before the eyes at the average reading distance, and you will note that you cannot read the top and bottom lines at the same time. Each line requiring a separate focus. This concentration is produced by the contraction of the pupil. The iris is known to be carried forward, by pressure from the anterior surface of the lens, which has become more strongly curved. Such lens pressure, the iris remaining inactive, would tend to increase the diameter of the pupil. On this account, greater efforts of the sphincter will be necessary to counteract this action of the lens-surface, when accommodation is present, than it would with accommodation relaxed.

The additional stimulus to contraction is undoubtedly due to the increased area of illumination. This would seem to imply that the contraction of the pupil not only responds to the light intensity (quality), but also to its area (quantity) upon the retina.

Light is imponderable. Its rays, reflected from various objects, pass through the cornea, the aqueous humor, the crystalline lens, the vitreous body and there reach the retinal nerves.

The delicacy of this touch or impact on the sensitive retinal nerves, is beyond the conception of the human mind, yet it establishes from this contact an impulse which is conveyed to the visual centers of the brain, which with no uncertainty, determine form, color, motion, quantity and space. How such vision is accomplished is a mystery.

It is also evident that the impairment of vision should be ascribed to that factor causing the largest area of diffusion upon the retina. Pupils differ in size in different individuals. The larger the pupil, the greater will be the zone of peripheral aberration and its correlated diffusion-area, and the more indistinct the vision. In fact, "the peripheral aberration upon the optical axis is known to increase, not only in proportion to the square of the aperture, but also with the degree of refraction" (physical law), so that we should have greater diffusion circles upon the retina, when the ciliary muscle is brought into action, even in emmetropia, to correct the peripheral aberration which impairs the sharp definition. The only stimulus which could assist in correcting the aberration in this case would be that which, imparted to the iris from the retina, would cause the pupil to contract sufficiently to exclude the peripheral rays. Asthenopia is therefore quite as apt to be experienced on account of the size of the pupil, as it is on account of the error of refraction.

It is questionable whether the eye can discriminate between images which are impaired by peripheral aberration and those which are illy defined from slight refractive errors. Thus: By placing a 1 D. convex lens before the emmetropic eye, it is practically rendered myopic for distance, the letters of the test-card at 6 m. becoming indistinct, with a probable reduction in the visual acuteness to say 6/9. If the lens be now covered with a pinhole disk, normal acuteness of vision will be re-established, with no other appreciable difference than that the field and illumination are less. With the pinhole disk applied, the small beam of light, uninterruptedly, strikes directly upon the center of the fovea centralis in the macula lutea of the retina. This is absolute, true, direct vision, which might well be termed central fixation, while the vision from the entire retina might be spoken of as eccentric fixation. If, therefore, increased aberration is to be avoided, the pupils must contract concurrently with accommodation.

In those cases of normal pupil, where the perceptive qualities of the retina are good, and the error of refraction is slight, retinal stimulus will prompt contraction of the pupil sufficiently to exclude aberration. Is it not probable that, in some cases with large pupils, protracted efforts of this kind would result in fatigue of the iris? Could not asthenopia be produced by that prolonged ineffectual effort of the sphincter, to regulate the volume of light upon the retina, to such a degree as shall be most agreeable to our light-perceptive sense, which strain would have to be in excess of the normal qualitative and quantitative light stimulus, to correct aberration?

The improvement in vision, which the myope, of low degree, with large pupils, secures by the lenticular correction, is practically due to the fact that the peripheral aberration is decreased, through reduced refraction obtained by the concave lens. The rays, emitted from the concave lens, enter the pupil with a divergence, counteracting the excessive convergence of the rays which are imperfectly focused by the crystalline lens upon the retina.

In those cases where the quarter-diopter lens seems to relieve distress it will generally be found that the pupils are comparatively large. And the larger the pupil, the more pronounced will be the improvement in visual acuteness obtained by low-degree corrections.

It is a common occurrence for a patient to wear a weak lens for a while, then lay it aside without feeling any discomfort, even though the optical error has not changed. Upon closer examination we frequently find that the pupils seem smaller than they were at the time the glasses were prescribed. The size of the pupil being the only apparent change, are we not justified in suspecting the iris, by reason of disturbed innervation, as having been at least implicated in the cause of asthenopia?

Injuries from sunlight and strong electric lights often result in chemical and atrophic changes which destroy the finer structures of the rods and cones of the retina, and the fibers of the optic nerves and tracts with even atrophy of the visual centers.

Snow-blindness has been ascribed as the result of irritation of the retina from prolonged exposure to light. The ultra-violet rays are held responsible for much of the damage to the eyes by various lights and flames.

Practically speaking: Of the five special senses that of sight is unquestionably the most important. What greater calamity can befall one than complete loss of vision. How sad for the individual, how pathetic for the observer, are the sightless days of those who previously enjoyed work, pleasures and the wonderful beauties of nature, dependent upon our most valuable possession, *perfect vision*.

Sight is not passive. It is an active function, and although we see apparently without effort or volition, yet every moment of vision is costing its adequate amount of vital energy. We think nothing of working our little delicate eye muscles sixteen or more hours each day, year after year, yet wonder why they feel tired at times, or how such strain could cause general ill-health, yet if we should work any other part of our body one-half so constantly we would be physical wrecks in short order.

Why are there more people wearing glasses today, than in any age in the history of the world? Simply because we are deviating farther from nature than ever before, taxing the eyes more and more, and as the result we are having to pay the penalty of weak, strained eyes, blurred vision, headaches, reflexes and glasses. A glass to the eye may be classed as a brace to a sprained ankle, to relieve the strain. Our forefathers never worked over small, close figures, under strong artificial illumination for hours, days and years as we do. They knew nothing of the constant strain of the moving picture show, nor the bright glare, sunshine and sand from an automobile, as well as many, many strenuous tasks we impose on our eyes every day and think nothing about it.

Science, no matter how scientific, benefits humanity little unless its findings can be crystallized into practical application. Therefore, by harnessing up this indirect vision when not needed, and relieving the eyes of a useless expenditure of accommodative power, we will render them more capable of producing even extremely strenuous work with less ill results.

I have a device which is a mechanical concentrator, and will relieve the muscular spasm in the act of accommodation. It consists of a cup shaped mounting or goggles, that fit close around the eyes so as to exclude all light, with an adjustable diaphragm before each eye. Open the diaphragms depending upon the distance from the object and size of field included, close the diaphragms until you exclude everything except that which you desire to see. This not only makes your vision clearer, but is very much more restful to the eyes. Just inside of the diaphragms there is a groove in which any individual's special correction lenses can be mounted. In this way it will not interfere with a refractive error, but will serve those who wear glasses as well as those who do not, and it will relieve and prevent eye-strain, as well as save eyesight.

*The American Journal of Ophthalmology.

Internal Motion in Spiral Nebulæ

Following the results of van Maanen, it is pointed out that Roche showed how a rotating gaseous mass with high central condensation would get flatter and flatter owing to shrinkage, until it became lenticular with a sharp periphery, after which matter would be ejected from the periphery. This view neglects tidal forces from distant stars, which, although small, may be represented by second harmonic terms, and tend to accelerate the effect; also to localize it at two antipodal points on the periphery. To a first approximation an ejected particle will describe an elliptic orbit of small eccentricity, and ultimately fall back to the main mass, but if tidal friction be considered it is found that such a particle will be gradually driven away from the main mass. On this view the nebular mass begins by being a lens-shaped figure in rotation, with matter streaming out at two opposite points and proceeding along spiral arms. The apparent angular velocity will decrease as the point examined passes along the arms, so that the spiral will appear to uncurl. The knots found on the arms are ascribed to the action of gravitationally unstable wave-motion.—J. H. Jeans, in *Observatory*.

Method of Preserving Butter

The butter is melted at 40° to 45° C., and the fat separated, and while still warm stirred with salt (30 grms. per pound of fat) which has been strongly heated and then cooled to about 45° C. The vessel is allowed to stand for two to three hours in a warm place so that the fat remains fluid, and the mixture is meanwhile frequently stirred. It is then filtered through cotton wool in a hot water funnel, and the filtered fat is placed in bottles, which should be filled to within one to two cm. of the stopper, and kept in the dark in a cool place. To reproduce the butter, the fat is melted at about 40° C., and 85 parts by weight is vigorously shaken with 15 parts of fresh milk for two to three minutes, and the emulsion is rapidly cooled by means of ice-water. Butter fat thus preserved will keep for at least a year.—Note from *Jour. Soc. Chem. Ind.* on article by T. Paul in *Chem. Zeit.*

Pale yellow coral mushroom (*Clavaria flava*).—This beautiful variety, plentiful in woods during warm wet weather, is easily known by its striking resemblance to branched coral. The flesh is white and the taste agreeable.

Edible *Boletus* (*Ceriomyces crassus*).—The reddish brown cap of this mushroom may be seen in July and August in woods, and at the borders of woods, and sometimes in open waste places. It has a pleasant nutty flavor even when raw.

Fairy-ring mushroom (*Marasmius oreades*).—Easily recognized by its habit of growing in circles. When young and moist it is yellowish red in color, becoming paler with age.

Foods Attractive to the Eye and Delicious in Flavor

Wild Mushrooms*

A Valuable Addition to Our Food Supplies

By William A. Murrill, Assistant Director of the New York Botanical Garden

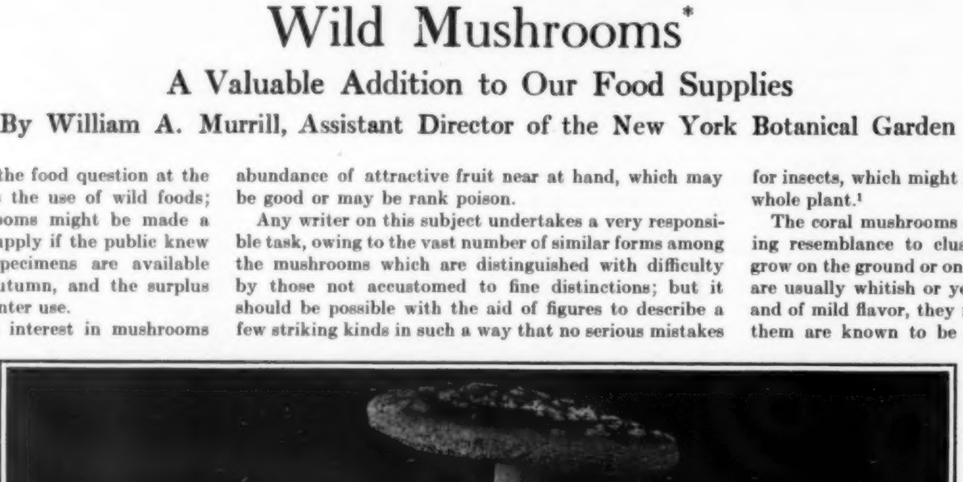
THE immense importance of the food question at the present time naturally suggests the use of wild foods; and many of the wild mushrooms might be made a valuable addition to our food supply if the public knew enough about them. Fresh specimens are available throughout the summer and autumn, and the surplus might be canned or dried for winter use.

The popular and widespread interest in mushrooms of all kinds is almost phenomenal. This is due to their beauty of form and color and the supposed mystery surrounding their origin and growth, as well as to the use of certain kinds for food. Their nutritive value is not very great, being about equal to that of cabbage, but they afford variety and add greatly to the relish for other foods.

Mushroom eating is much more common in Europe than in America. The struggle for existence is greater there, and the edible and poisonous varieties are better known by all classes of people. In China it is almost impossible for a botanist to get specimens on account of the thorough manner in which all wild food is collected by the natives. The use of mushrooms in this country is confined chiefly to our foreignborn population. Even in New York City, many excellent kinds go to waste because they are different from kinds known in Europe.

All knowledge regarding the edible and poisonous properties of mushrooms is based on experiments, either intentional or unintentional. The only safe rule is to confine oneself to known edible forms until others are proved harmless. If one is a beginner, he is like an explorer in a new country with an abundance of attractive fruit near at hand, which may be good or may be rank poison.

Any writer on this subject undertakes a very responsible task, owing to the vast number of similar forms among the mushrooms which are distinguished with difficulty by those not accustomed to fine distinctions; but it should be possible with the aid of figures to describe a few striking kinds in such a way that no serious mistakes will be made, even by the most uninformed beginner.



A showy and attractive plant, the fly amanita (*Venenarius muscarius*) is our most common poisonous species of mushroom. The color is bright red, scarlet, or orange in the young plant, fading to yellow on the margin, in the mature specimen while the cap is adorned with numerous white or yellowish warts. It grows both in woods and in open places from June until the freezing weather of October or November.

Fly Amanita, or Fly Poison

Pale Yellow Coral Mushroom.—Bushy, seven to fifteen centimeters high, five to ten centimeters wide; base thick fleshy, white, dividing abruptly into a dense mass of erect, pale yellow branches, the tips more deeply colored but fading with age; flesh white, mild, of good flavor.

This excellent, as well as beautiful, coral mushroom occurs rather abundantly in woods during warm, wet weather. In collecting it, the base should be examined for insects, which might give a disagreeable flavor to the whole plant.[1]

The coral mushrooms are easily known by their striking resemblance to clusters of branched coral. They grow on the ground or on rotten wood in dense shade, and are usually whitish or yellowish in color. When tender and of mild flavor, they make a delicious dish. None of them are known to be poisonous, although a few are insipid or bitter. Coral mushrooms may be cooked as other mushrooms are, or escalloped, or stewed slowly for half an hour with the usual seasoning and a little lemon juice, then thickened and cooked until tender.

Edible Boletus.—Convex, six to twenty centimeters broad, three to four centimeters thick; surface smooth, varying in color from ochraceous brown to reddish brown, sometimes paler; flesh compact, two to three centimeters thick, unchanging, white or yellowish, taste sweet and nutty; tubes white and stuffed when young, yellow or greenish yellow when mature, changing to greenish ochraceous when wounded, about two centimeters long; stem stout, becoming bluish or discolored when wounded, wholly or partially reticulate, solid yellowish within, five to ten centimeters long, three to four centimeters thick.

This excellent species of *Boletus* is abundant, well-known, and widely distributed in thin woods throughout temperate regions. The cap is large and usually yellowish brown, while the stem is more or less reticulate, especially above. In one variety, the stem is reticulate to the base, and in another the stem, as well as the cap,

*From *The American Museum Journal*, published by the Am. Museum of Natural History, New York. Illustrations from photographs by the Author.

[1]The golden *Clavaria* is similar, but more deeply colored. The rarer red-tipped *Clavaria* has red-tipped branches, the color of which fades out with age. There is also an unbranched club-shaped species which is often eaten.

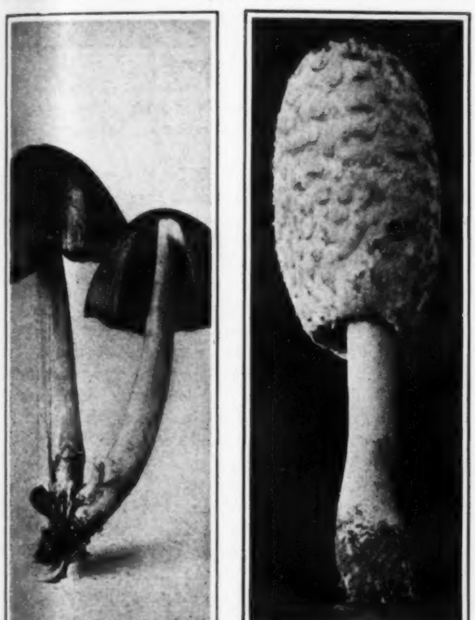
"Masked" *Tricholoma* (*Lepista personata*).—This large, lilac-tinted mushroom is of excellent flavor and not easily confused with dangerous species.

Oyster mushroom (*Crepidopus ostreatus*).—So named from color and shape, rather than for its flavor. Common on dead tree trunks, but not of first quality on account of its toughness.

Two Wild Foods for the Table in Summer and Fall

This mushroom (*Venenarius phalloides*) is the most dangerous of all fungi, and to it most cases of mushroom poisoning may be attributed.

Deadly Amanita



These two familiar examples are common in the rich soil of lawns and elsewhere in late summer and autumn, ink-cap (*Coprinus atramentarius*) being the more abundant. Shaggy-mane (*Coprinus comatus*), which is considered one of the very best and most digestible of the mushrooms, is conspicuous on account of its shape and its striking pinkish, reddish, and purplish tints, all often seen at the same time on one plant. Ink-cap is less attractive in appearance, and is more available for catsup than for other food purposes.

Ink-Cap and Shaggy Mane

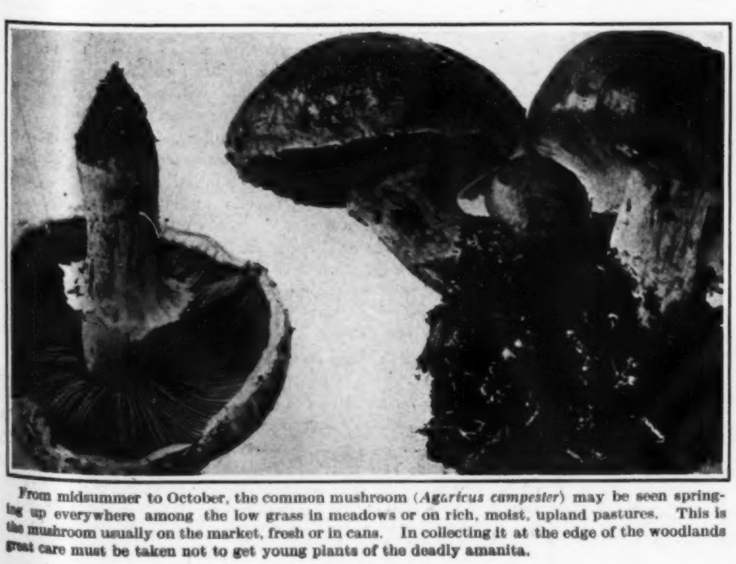
The "egg" of the poisonous stinkhorn mushroom (*Dictyophora duplicata*) in section, showing how it differs from a puffball. The stem and a green mass inside are surrounded by a layer of jelly-like substance, while the puffball in section is smooth and solid

"Perplexing" *Hypholoma* (*Hypholoma perplexum*).—The striking reddish clusters of this variety appear on stumps and roots of deciduous trees in autumn. Although the quality is inferior to some it is useful on account of its late appearance.

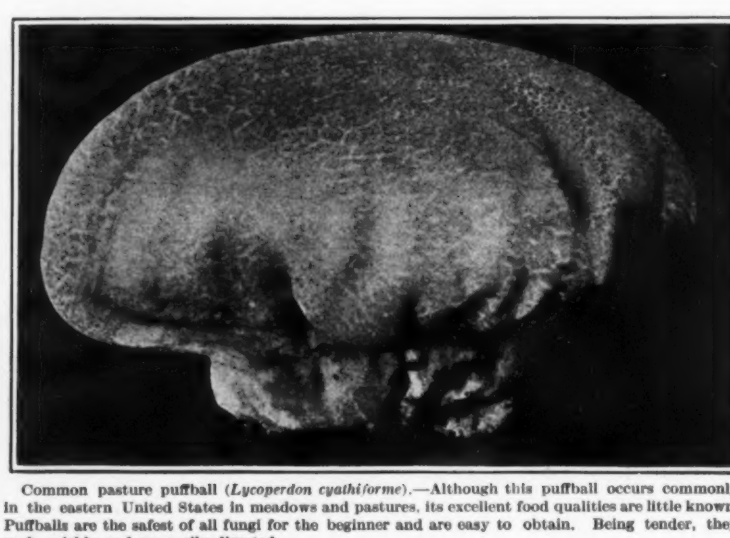
Two Wild Foods for the Table in Summer and Fall

White, yellow, brown and green forms may be found growing in woods, groves, open places, and bushy pastures, from July to October. It may easily be distinguished from the common mushroom, however, by the fact that the radiating gills underneath the cap are persistently *white*, those of the common mushroom being pink.

Another View of the Deadly Amanita



From midsummer to October, the common mushroom (*Agaricus campester*) may be seen springing up everywhere among the low grass in meadows or on rich, moist, upland pastures. This is the mushroom usually on the market, fresh or in cans. In collecting it at the edge of the woodlands great care must be taken not to get young plants of the deadly amanita.



Common pasture puffball (*Lycoperdon cyathiforme*).—Although this puffball occurs commonly in the eastern United States in meadows and pastures, its excellent food qualities are little known. Puffballs are the safest of all fungi for the beginner and are easy to obtain. Being tender, they cook quickly and are easily digested.

is brownish lilac in color. It may be distinguished from the bitter *Boletus* by its mild flavor and differently colored tubes. This species is much used in Europe, and is often sliced and dried for winter use. Large quantities are shipped to this country from Russia and elsewhere. It is best baked in a covered dish for an hour, after removing the tubes and stem and cutting it into small pieces.

Fairy-ring Mushroom.—Convex to expanded, slightly striate at times when moist, fleshy-tough, drying easily, two to five centimeters broad; surface buff or tawny, fading with age or on drying; flesh thin, white, of pleasant odor and taste; gills yellowish white; spores white; stem slender, tough, yellowish white, villose-tomentose, five to eight centimeters long, two to four millimeters thick.

The very excellent little fairy-ring mushroom is to be looked for in pastures during spells of wet weather in late summer or autumn. Its habit of growing in circles will aid one in recognizing it. It should be cooked for some time, owing to its tough texture.[2]

Oyster Mushroom.—Convex or nearly plane, irregularly fan-shaped, clustered, five to twelve centimeters broad; surface smooth, variously colored, usually white, yellowish, or brownish; flesh white, mild-flavored, somewhat tough; gills white; spores white tinged with lilac when shed on paper; stem eccentric or lateral, short or wanting, varying according to position in the cluster, strigose-hairy at the base.

The oyster mushroom is very common on dead trunks of deciduous trees, especially elm, from June to November. In Hungary, it is cultivated on sections of elm logs. The sapid mushroom is confused with it in this country and for our present purpose need not be distinguished, as its properties are similar. Both species are rather tough and lack flavor, but they occur in such large masses and are so readily recognized that they are to be recommended for general use as food. The young and tender caps should be selected and cooked slowly in a saucepan for at least twenty minutes.

"Masked" Tricholoma.—Thick, firm, convex to expanded, five to twelve centimeters broad; surface moist, lilac or purple, fading to grayish, becoming slightly brownish on the disk; margin inrolled and frosted when young; flesh white, firm, pleasant to the taste, becoming dull-colored with age; spores dingy white, dull pinkish in mass; stem short, solid, often bulbous at the base, lilac or violet, three to six centimeters long, one and one-half to three centimeters thick.

The "masked" *Tricholoma* is exceedingly valuable, of excellent flavor, and not easily confused with dangerous species. It may be found in open woods or among weeds or long grass in rich fields during the autumn months. Its large size and the violet or lilac tint of all its parts should distinguish it from most other species. In large, mature specimens, the flesh becomes soft and readily absorbs water during wet weather, which somewhat changes the appearance of the mushroom and lessens its value for edible purposes.

"Perplexing" Hypholoma.—Convex to nearly plane, clustered, five to eight centimeters broad; surface smooth dry, brick-colored to bay, the margin cream-colored to ochraceous; flesh usually of mild flavor, sometimes bitter, white or nearly so, becoming yellowish with age; gills sometimes slightly greenish, and finally purplish brown; stem straw-colored above, ochraceous or reddish below, six to ten centimeters long, five to seven millimeters thick.

The "perplexing" *Hypholoma* occurs abundantly on stumps and roots of deciduous trees in autumn, appearing in conspicuous reddish clusters of considerable size. It is edible, but not very good in quality, being useful because of its late appearance. In collecting this species for food, young and fresh specimens of mild flavor should be selected, and they should be cooked for at least thirty minutes. Soaking in water with a little vinegar for twenty minutes before cooking improves the flavor.

Common Mushroom.—Convex to expanded, five to nine centimeters broad; surface dry, silky, and whitish, or floccose-squamulose and light reddish brown, the color being chiefly in the scales; flesh white, thick, solid, of mild flavor, sometimes becoming reddish when broken; gills white when young, becoming salmon-pink, and finally brown or blackish; spores dark brown; ring delicate, inconspicuous, formed from a thin, white veil, which covers the gills in their younger stages; stem smooth, white, three to six centimeters long, one and one-half to two centimeters thick.

The common mushroom occurs in low grass in meadows or on rich, moist, upland pastures, being common after rains from August to October in this latitude. The "spawn," or vegetative portion, is hidden in the soil and feeds upon the dead organic matter found therein. In the cultivation of this species, bricks of spawn are planted in suitable soil and the conditions of growth attended to with great care.[3] This is the mushroom usually found in market, either in the fresh stage or in cans. Most persons who collect fungi for food in the fields limit themselves to this one species. Great care must be taken not to get young plants of the deadly amanita when collecting "buttons" of the common mushroom at the edge of woodlands. Also beware of the poisonous *Panæolus* which may appear in mushroom beds.

Common Ink-cap.—Ovoid to bell-shaped, finally expanding and deliquescing, densely clustered, three to six centimeters broad; surface smooth or slightly scaly especially on the disk, grayish or brownish, often with a yellowish tint, blackening with age; flesh white, quickly deliquescing; gills white when young, soon becoming black and dissolving; spores black; stem slender, smooth, white, five to ten centimeters long.

The common ink-cap is an excellent edible species and is quite common in rich soil on lawns and elsewhere during late summer and autumn. As it appears in close clusters, it may usually be obtained in greater abundance than the shaggy-mane. Owing to its deliquescent char-acter, it must be cooked very soon after it is collected.

Shaggy-mane.—At first oblong, expanding and deliquescing with age, four to six centimeters in diameter; surface shaggy, white, with yellowish or brownish scales, tinged with lilac in places, grayish black on the margin, blackening with age; flesh white, tender, of nutty flavor; gills white when young, soon changing to pink, then to black, and finally melting away into an inky fluid; spores black; ring white, small, movable or slightly adhering, often falling away at an early stage; stem slender, smooth, white, seven to twelve centimeters long.

The shaggy-mane is a very conspicuous object on lawns in autumn, although it is not always so abundant as might be desired. On account of its peculiar shape and decided colors, a single specimen rarely fails to attract attention. It is considered one of the very best and most digestible of the fungi, and is often eaten raw by foreigners. At times, this species occurs in enormous quantities in rich, loose earth by roadsides or in weedy places, and it then becomes an important source of food supply. It requires little cooking, and is best broiled and seasoned simply.

Common Pasture Puffball.—Large, rounded, five to fifteen centimeters in diameter, the base short and thick; surface smooth, whitish gray or brown, becoming purplish with age; spores purplish brown.

This puffball occurs commonly in the eastern United States in meadows and pastures where the common mushroom may be expected to grow, but its excellent qualities appear to be unknown to most persons. It is the largest puffball in this region except the giant puffball, which is much rarer. It sometimes grows in circles, and it has been known to be so abundant as to injure lawns seriously.

The giant puffball may be readily recognized by its large size, usually about the size of a man's head, and its smooth, white appearance. It occurs infrequently in fields, pastures, or woods throughout most of the United States.

Puffballs are the safest of all fungi for the beginner, none of them being poisonous; and they are at the same time excellent and easy to obtain. Being tender, they cook quickly and are easily digested. They should as a rule be cut open before cooking to see that they are not too old and that they are really puffballs. If they are white and firm like cream cheese inside, showing no yellow or brownish discoloration, they are of the right age to use. If the interior shows no special structures, but is smooth and homogeneous, then one may be sure he has a puffball. The "egg" of the deadly amanita contains the young cap and stem inside, which are readily seen when the "egg" is cut; and the "egg" of the stinkhorn shows the stem and a green mass inside surrounded by a layer of jelly-like substance.

Puffballs may be cooked alone in various ways, or used in stews and omelets, and for stuffing roast fowls. When used in omelets, they should be stewed first. All kinds except the very small one should first be peeled and cut into slices or cubes, after which they may be fried quickly in butter, or dipped in beaten egg and fried like egg-plant, or cooked in any of the ways recommended for the ordinary mushroom. The smaller kinds are much inferior in flavor to the larger ones and need a few specimens of some good mushroom to make them attractive.

[2]One should be very careful in picking small fungi growing on lawns for table use, to avoid getting *Inocybe infida*, a dangerous species with yellowish brown spores; and certain species of *Panæolus*, having black spores.

[3]The United States Department of Agriculture at Washington, D. C., will gladly furnish information regarding the cultivation of mushrooms in cellars during the winter months.

Ship Model Experiments*

Application to Full-Size Construction

It is sometimes taken for granted that when model experiments have been carried out on ships and propellers the application of the results to a full-size ship is comparatively a simple matter, and that all predictions for the ship based on the model figures will be fulfilled when the trial trip is run. There are, however, so many possible sources of uncertainty in going directly from the model to the ship that it is not always possible to guarantee the results to any great degree of accuracy. This is often the case with new types of vessels, and in ships where some features of the under-water form or propellers are novel.

SHIP RESISTANCE

The resistance of a ship is generally divided into four parts—the skin, caused by the friction of the water on the surface of the vessel, the wave making, the eddy making and the air resistance. By far and away the most important of these are the wave and skin resistances, and their comparative importance will depend on the relative speed of the vessel, that is, its speed in relation to its length. In low speed vessels the skin resistance may be as much as from 80 to 90 per cent of the total, and in moderate speed vessels from 65 to 80 per cent. The wave resistance increases with increase of speed, and it may be from 50 to 60 per cent. of the total in very high speed ships. Eddy resistance is usually slight, and if the stern endings of a ship are carefully designed it is a very small factor. Air resistance, unlike the other three, depends on the above-water shape of the vessel, and not on the under-water form.

When the model of a ship is run in an experimental tank the resistance measured is the sum of the skin and wave resistances; eddy resistance is generally absent, as the model is run with bare hull, and no appendages are present to cause eddies, while the air resistance is also negligible. It has been well established, chiefly by the late Mr. W. Froude, that the skin and wave resistance can be treated separately in going from the model to the ship. The skin resistance is calculated on the basis of friction experiments carried out on plane boards of various lengths moving through the water at various speeds, and coefficients have been established whereby the resistance of a surface of any length, moving at any speed, can be estimated. The wetted surface of the model is, therefore, calculated and the skin resistance deduced by taking coefficients suitable for the length of the model and its speed; the difference between it and the total resistance of the model is called the residuary resistance. To this Froude's Law of Comparison is applied, and the residuary resistance for the full-size ship obtained. The skin resistance of the ship is also estimated by reference to the coefficients mentioned, and the sum of the two should be—if all the assumptions made are correct—the total resistance of the ship.

SKIN FRICTION

Comparison between independent model results in different tanks shows that the accuracy obtained as between tank and tank is good, the errors of observation not exceeding three per cent. When, however, these results are applied to the full-size ship in the usual manner various disturbing factors are introduced. In the first place the assumption made for the skin friction is that the full body of the ship acts in the same manner as a plane board. It has, however, been demonstrated that this is not the case, and generally speaking the skin friction coefficient increases with increase in prismatic coefficient. Consideration of the stream line motion round a ship suggests a reason. Over the greater portion of the ship's side there is a general excess of rubbing speed in the water, due to the stream-line action, and a corresponding defect at each end, and the assumption is that the increased speed has a predominating effect, giving greater friction for the ship than for a board of equal length and area. Experiments carried out by Mr. G. S. Baker at the Froude experimental tank show that at the slowest practicable speeds models give a resistance exceeding that deduced for a corresponding plank by an amount varying from 5 to 20 per cent, and bear out the expectation that this excess increases with increase of prismatic coefficient. Until some more definite and general results have been obtained in regard to this effect, there must be some error involved in deducing the resistance of the ship from the model.

The plane boards used in the friction experiments of Mr. W. Froude did not exceed 50 ft. in length. To extend them to greater lengths it is assumed that the first 50 ft. has the same coefficient as that of a 50 ft. board, and that the remainder of the length, whatever it may be, has the same coefficient as the last foot of the 50 ft. board. A further assumption is made in extending the experiments to speeds much greater than the highest

*Engineering Supplement of the *London Times*.

used in the experiments. A correction should always be applied for difference of temperature between the water surrounding the model and the ship. Sir Archibald Denny has stated this as four per cent for 10 deg. F. on the whole resistance, and Mr. Baker uses a correction of three per cent, and Mr. Taylor about two per cent. for the same range of temperature, but taken on the skin friction only. Until recently this correction was not generally applied to trial results, principally because it was not known quantitatively.

As has already been remarked models are usually run without any appendages, and the appendage resistance is separately calculated and applied to the full-size ship, being based on separate experiments on models with appendages. There can be no doubt, however, that the resistance of some appendages, deduced in this way is somewhat exaggerated.

Air resistance is an uncertain quantity. It is now generally accepted that the resistances of equal areas in air and water at equal speeds are proportional to their densities, and air is about 1-800th as dense as water. No satisfactory methods have been devised for estimating the air resistance of a ship. So far back as the seventies Mr. W. Froude made some experimental investigations on the Greyhound, a vessel 172 ft. long. At 10 knots, and without masts and rigging, the air resistance was about 1½ per cent. of the water resistance. In this vessel the top hamper was not excessive. In moderate and high speed vessels with a large amount of top hamper this figure will be exceeded. The resistance referred to is that caused by the vessel's own movement through the air, which is assumed to be at rest as in ideal trial trip conditions.

FORM AND RESISTANCE

Model experiments make it possible to design an under-water form for minimum resistance to motion in the tank. Practical considerations enter here, however, and it is not always possible to adopt exactly the "best" form derived from tank experiments. If often happens that appreciable variations from this "best" form do not materially add to the resistance of the vessel. In such cases it is hardly worth while sacrificing some other feature of the ship in order to obtain this special under-water form. Gains in resistance of the order of five per cent may appear attractive from the point of view of economy, but it is not certain that such savings will in fact be realized in the full-size ship. Errors of one to two per cent are possible in the readings obtained with the model, and others can creep in to disturb the values deduced for the ship from the model. There can be no doubt, however, that very bad forms can be improved, by model experiments, and savings of 10 per cent and more have been recorded. If this were the only advantage arising from model tank experiments—and it is not—they would be amply justified. These remarks refer to resistance in still water. The question whether the best form for propulsion in still water is also the best for propulsion at sea is a vexed one and no more will be said about it here than that a full midship section and fine ends, so often found desirable for easy propulsion in a tank, are not, by general consent, found to be an advantageous combination at sea. Fuller ends make a vessel kinder to a sea, and the finer midship section enables her to maintain her speed better in rough water.

PROPELLER EFFICIENCY

Propellers are designed by reference to the results of experiments carried out on model propellers in testing tanks, and the ordinary law of comparison is assumed to hold good. Actual measurements that have been made with propellers similar in every respect, but different in absolute size, show that differences, only varying from two to four per cent, are possible in thrust and efficiency, as deduced from the law of comparison, and from these results it is assumed that the law holds good. Some question as to the accuracy of this assumption has been raised in a subsidiary way at different times. The law certainly fails when a propeller breaks down by cavitation, and Mr. Taylor in his book on "The Speed and Power of Ships" considers it probable, particularly with blunt-edged blades, that there is more often than might be supposed a certain amount of eddying in the operation of the full-size propeller not found in the operation of the model. Mr. A. W. Johns, in a paper read this year at the Institution of Naval Architects, is even more emphatic. After establishing the similarity between propeller action in air and water, he shows that for aerial propellers the thrust does not increase in all cases with the second power of the speed. His conclusions agree with Mr. Taylor's that for narrow blades the thrust varies at a greater power than the square of the speed, while for wide blades it varies at a smaller power than the square. Mr. Johns also drew attention to the increase of efficiency with speed in the aerial propellers, and saw no reason why this should not hold good for propellers in water, although no account of it is taken at present. The variation observed is considerable, being as much as from 7 to 20 per cent at the slip ratios found in practice with ship's propellers.

The assumption made in connecting up full-size propellers with model ones is that the shaft horse-power absorbed by the propeller is the same for the same thrust and revolutions whether the screw is working in open water or in the disturbed water behind the ship. This condition is not always realized, and the ratio of the shaft horse-power absorbed by the propeller in the open to the actual shaft horse-power required when the propeller is behind the ship is called the relative rotative efficiency. Its value is generally considered to be unity—or practically so—but this conclusion has been more or less arrived at by experiments with vessels of war, in which the lines are moderately fine and the appendages are reduced to a minimum. In merchant vessels, with fuller lines and large shaft bossings, few reliable results are available, but it seems reasonable to assume that this efficiency will show a greater variation from unity than it does in warships. This variation indicates a change in the efficiency of the propeller behind the ship as compared with its efficiency in open water, and one of the reasons for the alteration is that the wake over the screw disc is not uniform. In addition, the propeller may not be advancing along the axis of the shaft, although this will not generally have such an important effect as lack of uniformity in the wake.

WAKE AND EFFECTIVE PITCH

In designing a ship's propeller it is necessary to form some idea of the wake factor. Few experiments have been carried out on models to determine this figure, although a good deal of useful work has been done. It is unfortunate, however, that the wake values as deduced from the models cannot be directly applied to the full-size ship, as the value would not be the same. When the propellers are moderately close to the hull the model wake will exaggerate that existing in the ship. There is still another difficulty in applying model propeller results to the full-size propeller. It is well known that the effective pitch of any propeller is not the same as the face value to which the propeller is cut. In Mr. R. E. Froude's model experiments he found that the effective pitch was about 10 per cent greater than the nominal pitch, and to apply his results to full-size screws he recommended that two per cent should be added to the nominal (or face) pitch for design purposes. With screws in turbine vessels Mr. G. S. Baker considers that this addition should be four per cent. This correction is assumed to be independent of speed. Sir Archibald Denny, however, in a recent utterance, considers that the discrepancy between effective pitch and that of the driving face varies with speed of advance, with the width and shape of the blade, and with its thickness, and if the section of the blade be not symmetrical about its center the real (or effective) pitch may vary greatly from the face pitch. He is also of the opinion that it is not correct to take the real pitch at any particular speed of advance as being that pitch at which the propeller gives no thrust. This latter assumption is made by Mr. R. E. Froude in all his work. It will be seen therefore that considerable doubt exists as to what is the effective pitch to use in propeller design, and this is the more unfortunate since variation in pitch affects the propeller efficiency, particularly at large slips.

THE VARIATIONS IN PRACTICE

That these variations may have considerable effect on the full-size ship is easily demonstrated. The propulsive coefficient of a ship is the ratio which the effective horse-power, as deduced from model experiments, bears to the total horse-power of the engines, and if all the efficiencies obtained in work with models were applicable to the ship and her propellers, this propulsive coefficient should be the product of the hull efficiency, the propeller efficiency, and the relative rotative efficiency—if we are dealing with shaft horse-powers. Actually, this is generally a long way removed from the truth, and the error may be as much as from 10 to 20 per cent. It is apparent therefore, that the propulsive coefficient to be used in deciding the final horse-power of a ship cannot be predicted from the model results.

Should a ship similar to the new vessel be in existence and model results be available for it, the actual propulsive coefficient can be deduced from the type ship and the figure used for the new one. If trial data of a somewhat similar vessel are already available there is another method open which has the advantage of giving the designer a reliable basis for his estimates, when model experiments for the ship under consideration would be out of the question. It depends on the use of Taylor's "Standard Series" of model experimental results. It is true that the "Standard Series" curves have been proved to give inaccurate values in many cases when applied to ships differing from the Standard form; the figures being generally less than the actual. The effective horse-power so obtained therefore would not be correct in actual value, but when used in connection with the trial horse-power of a vessel it would give what Mr. Taylor calls "a nominal efficiency of propulsion." If the new ship is not very far removed from the type ship the percentage error in estimating the nominal effective horse-power will be approximately the same in each case, and in consequence the new horse-power can be predicted within narrow limits. This nominal propulsive coefficient allows for actual loss of efficiency in the propeller and other disturbing elements enumerated, provided they are of proportional value in both vessels. In any case this is the assumption made in working from one vessel to a similar one, after model experiments have been made for both ships.

A similar "Standard Series" of experimental results on model propellers is very generally used for propeller design, although the wake value for the ship cannot be accurately predicted. Small variations are not always serious, as the efficiency of the propeller does not vary appreciably over a good range of slip ratios, provided these are in the region of maximum propeller efficiency.

It is generally admitted that much work remains to be done on ship resistance and propulsion. Many unknown factors exist, but it is to further model tank experiments, coupled with careful analysis of trial results and possibly experiments on full-size ships, that designers must look for guidance.

Air Pollution in London

INVESTIGATIONS of the pollution of the air of London, and other cities in England, are in progress, and from reports so far made the following information is derived:

The standard method which has been employed for these observations depends upon the use of an enlarged type of rain-gage, and the measurement and examination of the whole of the suspended and dissolved solid matter which collects in the bottles attached to this gage at monthly intervals. The examination of the collected rain water covers the estimation of the insoluble constituents, such as tar, carbonaceous matter, and ash, and of the soluble, such as combustible matters, chlorides, sulfates, and ammonia.

Considerable criticism has been directed against this method of observation, on the ground that it does not record the suspended amount of air pollution, but only that carried down by the rainfall, and that the variation in the figures obtained is due chiefly to local variations in the latter. It is, however, pointed out that the mount of deposit found in the gages is not altogether dependent upon the rainfall, and that, even in dry weather, a considerable amount of solid matter falls into the gages by gravitation. The whole question of the relation of the amount of the deposited impurity to the rainfall has been dealt with at some length with the aid of the collected figures for 1914–1916, and it has been proved that, while the soluble portion of the deposited matter is considerably affected by the rainfall, the insoluble deposit is to some extent independent of it.

The mean monthly deposit in London, *i.e.*, the average of all the London stations, for the summer of 1914–15 was 27.90 tons per square mile, and for the winter 29.18 tons, whereas for the corresponding periods of 1915–16 it was 34.32 and 40.87 tons respectively, showing a marked increase in both seasons. The mean monthly deposit for the whole year in London in 1914–15 was 28.56 tons per square mile and 37.60 tons in 1915–16, an increase of over 30 per cent.

The comparative figures for "tar" are of interest, for tar is the ingredient of atmospheric pollution which is the most objectionable from the householder's point of view, the rapid deterioration of paint and of curtains being chiefly due to this ingredient of town atmospheres. The mean monthly deposit of tar in the Embankment Gardens, London, for 1915–16 was 0.96 ton, equivalent to 11.52 tons per square mile for the twelve months. The figures for "carbonaceous matters other than tar" (*i.e.*, unburnt particles of coal, smuts, and soot), for the Embankment Gardens' collecting station, averaged 11.87 tons per month, equivalent to a fall of 142.44 tons per square mile per annum.

Taking the case of the County of London alone for 1915–16, and basing the figure upon the average return from the different observing stations, the total quantity of matter deposited on London from the air during the year was approximately 54,200 tons, and this deposited matter is largely derived from fuel waste in the form of smoke. The six months, April to September, were responsible for about 24,900 tons, and the six months, October to March, for 29,300 tons.

Not only is it necessary at present to scrutinize carefully every source of waste, but it is equally necessary to conserve the health and physical energy of the people; and it may not be out of place in this connection to mention that the approximate quantities of air, solid food, and water required by an adult human being per day are, air, 30lb.; food, 2.7 lb.; water, 4½ lb.

The Development of the Coherer*

And Some Theories of Coherer Action

By E. C. Green

THE electric wave detecting device, first known as a Branly tube and later as a coherer, has been the subject of much research. Many experimentalists in past years noticed that a number of metals, when powdered, were practically non-conductors when a small electromotive force was impressed on the loosely compressed particles, while they became good conductors when a high electromotive force was applied.

This knowledge can be traced as far back as 1835 to Monk of Rosenschceld[1] who described the permanent increase in conductivity of a mixture of tin filings, carbon and other conductors, due to the discharge through them from a Leyden jar. It seems that no attention was given to Rosenschoeld's observations at that time.

In 1852, S. A. Varley observed the high resistance of a mass of loose metallic powder and, it is said, four years later during a thunderstorm he noticed a very remarkable fall in its resistance.[2]

In 1866, C. Varley and S. A. Varley obtained a British Patent No. 165 in the specification of which was described a device for protecting telegraphic instruments from lightning. This device consisted of two copper points, almost touching each other, set in a small box filled with powdered carbon. They stated that powdered conducting matter offers great resistance to the flow of current at moderate voltage, but offers little resistance at high voltage. Even this announcement failed to create much attention.

Some very important observations were made by Prof. D. E. Hughes in 1878, while engaged in research work on the microphone.[3] In some of his experiments he used a tube of glass, filled loosely with zinc and silver filings, placed in series with a telephone and a single voltaic cell. Hughes seems to have discovered the very important fact that such tubes, when so used, were sensitive to electric sparks at a distance, as indicated by their sudden change in resistance. He showed these experiments privately to many scientific friends, but it was about twenty years later before his results were made public.[4] In the meantime other scientists had observed the same facts. In Italy, Prof. T. Colzecchi-Onesti made experiments on the changes in resistance of metallic powders. loosely compressed, under the action of various voltages. These observations were described in full in the Italian Journal, Il Nuevo Cimento, 1884 vol. 16, p. 58, and vol. 17, p. 35. He did not add very much, however, to observations already made by the Varley brothers.

In 1890, Prof. E. Branly of Paris published an account of a very comprehensive series of observations on the same subject that confirmed the work of previous observers and added a great deal of new information.

While Professor Hughes seems to have discovered the fact that loose masses of powdered conductors are sensitive to electric sparks at a distance, it remained for Professor Branly to make conclusive observations and thoroughly demonstrate this fact. In the majority of common metals he observed that the electric spark caused an increase in conductivity, while a few metals exhibited a decrease in conductivity,[5] such as the contact between lead and lead peroxide. To Professor Branly belongs the honor of giving to science a new weapon in the form of a tube or box containing metallic filings rather loosely packed between metal plugs. This tube was known as the Branly Metallic Filings Tube or Cymoscope, and is shown in diagrammatic form in Fig. 1.

He also showed that such a tube may be a conductor of very low conductivity when the filings are loosley arranged, but that the conductivity of the filings is suddenly increased by a nearby discharge of a Leyden jar or by any other nearby electric spark.

He used a galvanometer in series with such a tube and a single cell to detect the changes in conductivity. When an electric spark was made at a distance the galvanometer needle would become suddenly deflected, showing the greatly increased conductivity.

Branly observed that the same effect occurred in the case of two slightly oxidized steel or copper wires crossed in light contact, and further observed that this contact resistance dropped from several thousand ohms to a few ohms when an electric spark was produced many yards away.

Branly's work did not secure the notice it deserved until 1892 when Dr. Dawson Turner described Branly's experiments and his own additions to them, at a meeting of the British Association in Edinburgh.[6]

After the reading of Dr. Turner's paper Prof. George Forbes raised a very important question by asking whether it was not possible that Hertz waves might in a similar manner break down the resistance of a tube of loose metallic fillings. This question showed that the real cause of coherence was not fully comprehended at that time.

In 1893, W. B. Croft exhibited Branly's experiments at a meeting of the Physical Society in London and read a

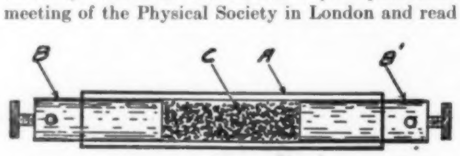


Fig. 1—Branly metallic filings tube. A, insulating tube; B, B[1], metal plugs; C, metallic filings, loosely packed

paper on "The Action of Electric Radiation on Copper Filings."[7] In the exhibition of Branly's experiments Croft used a glass tube filled loosely with copper filings, connected in series with a galanometer and a battery. No current passed when the filings were loosely arranged, but when a spark was made nearby the galvanometer deflected, showing the passage of current, and remained so until the tube was tapped back into a non-conducting state. This paper brought up the question as to how the electric spark caused the change in conductivity. Mr. Croft stated that the filings tube changed to a conductive state before the actual spark passed when the static electrical generator was started. Some thought the light from the spark caused the action.

In the same year, Prof. G. M. Minchin read a paper entitled "The Action of Electromagnetic Radiation on Films containing Metallic Powders."[8] In this paper Minchin made special reference to the Branly tube,

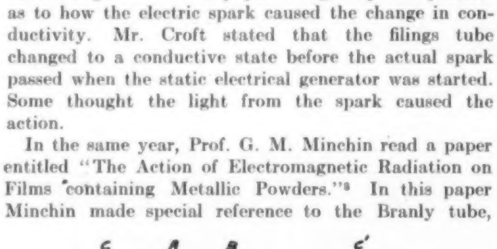


Fig. 2—Lodge coherer. A, glass tube; B, iron filings or borings; C, C[1], metal plugs; D, insulating base

and stated that: "The waves sent out from the spark at once render the column [of metallic filings] a conductor."

It seems clear, therefore, that at the end of 1893 Professor Minchin and a few other physicists had clearly recognized that the action discovered by Branly had its origin in electromagnetic radiation.

This paper was followed by one from Sir Oliver Lodge, entitled "On the Sudden Acquisition of Conducting Power by a Series of Discrete Particles."[9] In his discussion, allusion was made to an observation he had frequently made in connection with his experiment of the Syntonic Leyden jar; viz., to the effect that if the two metal knobs of the receiver were very close together, a battery and electric bell being in series, the occurrence of an electric oscillation in the circuit caused the knobs to make a good contact and cause the electric bell to ring. This action was produced entirely by electric radiation.

In June, 1894, Lodge gave a lecture at the Royal Institution, entitled "The Work of Hertz."[10] In this lecture, the Branly tube was again described and several were exhibited. Lodge was the first to give the name Coherer to the Branly tube, a follows: "*A coherer is a device in which a loose or imperfect conducting contact between pieces of metal is improved in conductivity by the impact on it of electric radiation.*" Lodge's lecture caused widespread interest in Branly's discoveries and pointed out more forcibly that a new and highly sensitive means of detecting electric radiation had been evolved. The coherer used by Lodg consisted of a glass tube 1 cm. or less in diameter and about 7 cm. long, filled loosely with coarse iron filings between two metal plugs. A diagram of this tube is shown in Fig. 2. He also tried brass borings and various other metals, filling the tube with air, hydrogen and even sealing it off at a vacuum. Lodge also experimented with various forms of light contact coherers, such as a steel sewing-needle resting lightly on an aluminium plate, and also slightly oxidized steel rods in light contact.

Up to this time the coherer was found to be a very capricious instrument; in instances highly sensitive to electric sparks, and then, all conditions being apparently

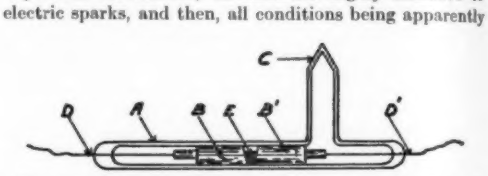


Fig. 3—Marconi coherer. A, glass tube exhausted; B, B[1], metal electrodes; C, side tube for exhaustion; D, D[1], platinum terminal wires; E, nickel-silver granules

the same, it became far less sensitive. The metals forming the most reliable coherers were iron, steel, nickel, copper, brass and zinc, while the noble metals were much less reliable.

The man who really made the coherer famous, G. Marconi, began his work in Italy in 1894 and devoted his attention to the further development of the Branly coherer. He made a systematic and scientific study of the relative advantages of various metals as coherer material and selected for his work a mixture of 95 per cent nickel and five per cent silver filings carefully sifted to the same degree of fineness. He also modified his coherer tube, Fig. 3, very greatly from that previously used by other experimenters.[11] Instead of a long tube of large diameter as used by Lodge, he used a tube, *A*, 3 or 4 cm. long, having an internal diameter of 4 or 5 mm. He placed in this tube two silver plugs, *B*, *B'*, with edges beveled, highly polished, and slightly amalgamated with mercury. This gave to the interspace a wedge shape, the large part being at the top of the tube and about 2 or 3 mm. wide. This interspace was about half-filled

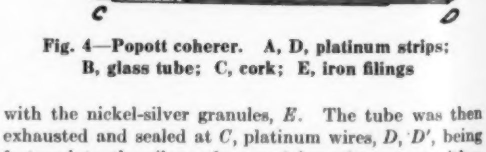


Fig. 4—Popott coherer. A, D, platinum strips; B, glass tube; C, cork; E, iron filings

with the nickel-silver granules, *E*. The tube was then exhausted and sealed at *C*, platinum wires, *D*, *D'*, being fastened to the silver plugs and brought out at either end. This tube was much more sensitive and reliable as an electric wave detecting device than anything that had previously been designed.

Marconi then proceeded to work out devices for employing his improved coherer as a relay upon a relay in a telegraphic outfit for receiving wireless messages. This last application caused world-wide interest in the coherer and numerous experimenters began work upon it.

Prof. A. S. Popoff of Russia in 1896 used his filings coherer to study the phenomena of atmospheric electricity, and also used it to detect and make records of lightning discharges at a distance. His coherer, a diagram of which is given in Fig. 4, was made of a glass tube, *B*, with two platinum leaves, *A* and *D*, down opposite sides, the intervening space being loosely filled with iron filings, *E*. The tube was then corked up at *C*.

Toward the close of 1896 Guglielmo Marconi left Italy for England and there explained his wireless

*Republished from the *General Electric Review*.

[1]See paper read before the St. Louis International Electrical Congress, 1904, by K. E. Guthe, on "Coherer Action."

[2]See *The Electrician*, vol. 40, page 86.

[3]See D. E. Hughes, Proc. Roy. Soc. Lond., May 9, 1878, vol. 27, p. 35.

[4]See Prof. Hughes' letters in *The Electrician*, May 5, 1899.

[5]See E. Branley, *Comptes Rendus*, 1890, vol. 111, p. 785, also 1891, vol. 112, p. 90, or *The Electrician*, 1891, vol. 27, pp. 221, 448.

[6]See Dr. Dawson Turner, *The Electrician*, 1892, vol. 29, p. 432, "Experiments on the Electrical Reistance of Powdered Metals."

[7]See W. B. Croft, Proc. Phys. Soc Lond., vol. 12, p. 421.

[8]See Prof. Mimchin, Proc. Phys. Soc. Lond., Nov. 24, 1893, vol. 12, p. 455.

[9]See Proc. Phys. Soc, Lond., 1893, vol. 12, p. 461. Also Phil. Mag., Jan., 1894, vol. 37, p. 24.

[10]See Proc. of the Royal Institution, 1894, vol. 14, p. 321.

[11]See British Patent Specification of G. Marconi, No. 12039, June 2, 1896.

coherer apparatus to Sir W. H. Preece, then the Engineer-in-Chief of the British Government Telegraph Department of the Great Post Office. Preece delivered a lecture before the Royal Institution on June 4, 1897, at which he exhibited Marconi's apparatus and stated that: "Marconi has produced from known means a new electric eye, more delicate than any known electrical instrument, and a new system of telegraphy that will reach places hitherto inaccessible."[12]

After this, many well-known scientists constructed various forms of coherers, most of which were designed for more rapid operation so as to be more adaptable for wireless work. Some were made of steel and mercury, copper and mercury, carbon and mercury, ball coherers, single contact coherers, etc. These were all low-voltage coherers, having a critical voltage of from 0.3 to 3 volts.

De-coherence was produced in the metallic filings coherer by tapping, slowly revolving the coherer tube, attaching the coherer to the armature of a relay, by clock-work tappers, etc. Marconi's scheme for producing de-coherence is shown in Fig. 5. It seems T. Tommasina was the first to use electromagnetic means directly for producing de-coherence.[13] He placed an electromagnet over the tube and in series with the coherer so that when the tube became sensitive the magnet was energized and lifted the granules to the top of the tube, thus producing de-coherence. This was applied to iron, nickel and cobalt coherers.

Various ingenious schemes have been developed for varying the sensitiveness, or critical voltage, of these coherers. Marconi made use of the wedge-shaped electrodes, B, B', Fig. 3, in his coherer tube to produce this change. By taking hold of the sealed-off glass projection, C, the tube can be turned on its axis into various positions, so that the filings lie in a broader or narrower portion of the gap between the bevelled silver electrodes.

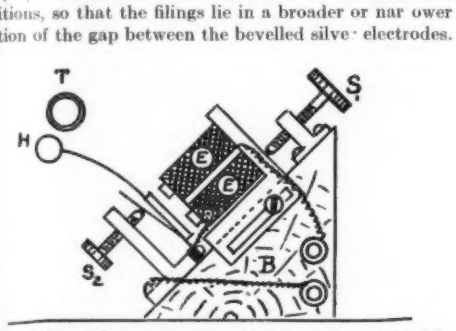


Fig. 5—Marconi's electromagnetic tapper for tapping his sensitive tube to a receptive condition. E, E, electromagnet; H, hammer; T, sensitive tube shown in cross section; S_1, S_2, adjusting screws

M. Blondel made a coherer with a side pocket into which some of the granules could be shaken from between the electrodes, or vice versa. This coherer is illustrated in Fig. 6.

In the various types of single-contact coherers the degree of sensitiveness was altered by changing the number of such coherers in series.

When the Consulting Engineering Laboratory of the General Electric Co. took up the development of a coherer to be used in connection with discharge alarms for lightning arresters, high frequency alarms, etc., the problem had previously been the design of a coherer that would be as sensitive as possible and yet act reliably. The alarm coherer presented an entirely different problem. The task now was to make the coherer less sensitive and to shield it from all wireless effects so it would only respond when voltage was present, not due to Hertzian waves but due to direct contact with an energized source of voltage.

As the result of exhaustive experiments with aluminum, copper, magnesium, cobalt, iron, nickel-plated lead shot, tungsten, molybdenum, nickel, silver, and various other metals, 40-60 mesh pure nickel granules were selected. These were oxidized and sealed off in a tube containing a sufficient amount of gas to stabilize the oxidization of the granules. This residual gas thus prevents a rise in the critical voltage. The tubes may have a critical voltage of from 10 to 700 volts, depending upon how far the oxidization of the granules is carried.

After experimenting with tapping, rotating, and electromagnetic means of de-coherence, it was decided to use a tube shaped as shown in Fig. 7 and surrounded by a solenoid. This construction serves a double purpose in de-cohering the tube, for it lifts the granules away from the electrodes sealed in the bottom of the tube, thus breaking the circuit through the coherer, and then shakes up the granules and rearranges them by dropping them back when the solenoid is de-energized. Only one operation of this de-cohering device is necessary to produce perfect de-coherence in every case; while by the tapping method current continues to flow through the granules while being tapped and it often requires a number of operations to produce like results.

The sensitiveness of this coherer may be fixed by the amount the granules are oxidized and by the length of the "pantlegs" on the coherer tube.

To prevent the coherer from operating due to wireless effects, a high critical voltage coherer has been developed and in each lead running to it is placed a spark-gap which is set at such a value as to prevent any accumulation of static voltage from jumping over and reaching the tube The coherer circuit is also operated by means of dry cells placed close to the coherer to cut down the antennae effect of the leads. The contact on the armature of the small relay in series with the coherer tube has been insulated from the armature, so as to prevent surges being set up in the relay winding by current flowing through the armature and core of the relay.

These combined precautions make the present form of coherer very reliable and quite free from wireless effects.

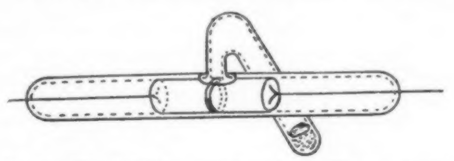


Fig. 6—Blondel side-pocket metallic filings coherer

In the best of former coherers a very slight leakage current was always noticeable; in the present coherer no deflection of a microammeter needle can be observed when 100 volts is applied to the terminals of a coherer having a critical voltage of 150 volts, while the operating voltage of the coherer circuit is only six volts. This demonstrates the great factor of safety as to leakage current.

The volt-ampere characteristics of one of these coherers is shown in Fig. 8.

THEORIES OF COHERER ACTION

A few of the theories that have been advanced to account for the phenomenon of coherence under the impact of electromagnetic waves will be briefly dealt with.

It is clear that the agency which actually causes coherence is electromotive force, and that the problem to be explained is the reason why electromotive force when acting on certain materials which are in light, or imperfect contact, brings the contact surfaces into a better conducting state while with a few other substances the action reduces the conductivity.

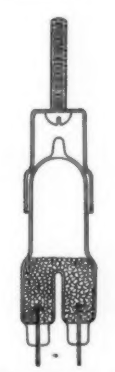


Fig. 7—Coherer which forms a part of discharge alarm and high-frequency alarm devices

At an early date Lodge advanced the opinion that coherer action was due to the welding together of the metallic surfaces in light contact. Many observers claim this process can be witnessed through the microscope. This theory of welding, however, does not explain how highly oxidized granules or carbon dust coheres, as it is impossible to weld either of these at such temperatures as are present in these cases.

T Sundorph[14] claims that in the filings coherer the action is due to the formation of conducting chains of particles stretching between the electrodes. T. Tommasina supports this theory and says these chains are more easily formed when the surrounding medium is distilled water, or some dielectric other than air.[15] In these experiments it seems that a considerable potential difference must have been employed, far in excess of that necessary to cause coherence.

This theory of conducting chains does not show why some substances, such as potassium, arsenic, lead and lead peroxide, etc., become less conductive, and therefore does not satisfy the requirements.

Lodge has shown that two conductors separated by a film of air one ten-thousandth of a millimeter thick, and having a difference in potential of one volt, are drawn together by electrostatic attraction with a force of 646.8 pounds per square centimeter of contact surface.

He claims this force squeezes out the gaseous dielectric film separating the granules and thus causes coherence. This, however, also fails to show why other substances exhibit the negative conducting qualities under similar conditions.

Another theory of coherer action is based on the electronic theory of electricity. According to this theory, the conduction of electricity in conductors is due to the motion of free electrons, or negative ions, in them. In each conductor there is a certain number of these free ions per unit mass. The following is taken from Fleming's "Principles of Electric Wave Telegraphy and Telephony," second edition, page 445.

"Sir J. J. Thompson has shown that an ion cannot fly off spontaneously and leave the conductor in which it is located,[16] since the instant it attempts to depart from the surface it is subjected to a force which is numerically equal to $\frac{e^2}{4d^2}$, where e is the ionic negative charge (viz., 3.4×10^{-10} electrostatic units) and d is the distance from the surface. Now suppose that two metal surfaces are very near together, and at a difference of potential of V volts, or $\frac{V}{300}$ electrostatic units. Let the distance between these surfaces be microscopic, and equal to X

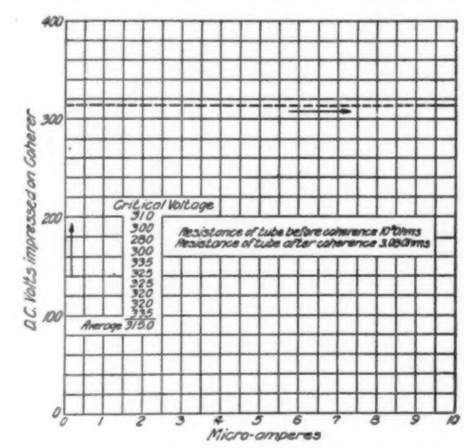


Fig. 8—Volt-ampere characteristic curve of G-E coherer No. 1065

cm. Then the electric force in the intervening space is $\frac{V}{300X}$ electrostatic units, and if this is equal to or greater than $\frac{e^2}{4X^2}$ then negative ions may pass from one mass of metal into the other and thus cause current to flow.

For example, if there is such a value of X and V that $\frac{V}{300X}=\frac{e^2}{4X^2}$ or $X=75\frac{e^2}{V}$, this transference of ions can take place. Moreover, when this transference of ions begins, it increases the potential difference between the two masses and this causes them to be drawn still closer together by electrostatic attraction.

When very great differences in conductivity exist between the two surfaces in contact, the action may result in the accumulation of negative ions at the bounding surface in such a manner as to stop the flow of current across the junction. This would explain the decreased conductivity between lead and lead peroxide."

Some of the latest experimenters claim that there can be no passage of ions from one conductor to another unless the surfaces are really in contact, so it seems the real way in which coherence occurs is still a problem to be solved.

New Zenith Telescope

Most of the instruments in present use for zenith measurements depend in some way or another on a telescope adjusted on the nadir by means of reflection, or by a level, or by a plumb-line, and in general the telescope is liable to flexure or change of collimation during the movement from one position to another. A form of instrument is designed to avoid these disadvantages, consisting of two telescopes rigidly connected, parallel to each other, one with objective pointing to the zenith, the other towards the nadir. The whole is mounted so as to permit of rotation through 18° about a vertical axis, so that no change with respect to gravitation is involved. —Note in *Science Abstracts* on a paper by G. Biogourdan in *Comptes Rendus*.

[12]See *The Electrician*, vol. 39, p. 217.

[13]See *Comtes Rendus*, 1899, vol. 128, p. 225.

[14]See *Wied Annelen*, 1899, vol. 68, p. 594.

[15]See *Comtes Rendus*, 1899, vol. 129, p. 40.

[16]See "Conduction of Electricity Through Gases," p. 144.

The Brown Coal Distillation Industry of Germany—II*

Methods Apparatus and Products Resulting

By D. R. Steuart, F.I.C., F.R.S.E.

Continued from Scientific American Supplement, No. 2181, Page 256, October 20, 1917

The crude oil is sometimes treated chemically before distillation, and, if so, slaked lime or caustic soda ($\frac{1}{4}$ to $\frac{1}{2}$%) is added to the charge. Manganese oxide and bleaching powder have been tried to lessen the creosote and remove the sulphur; but although the creosote is reduced and the smell is improved the sulphur is left as before. A 2 or $2\frac{1}{2}$ ton charge is distilled in 19 hours; the coke is removed by broad iron spades and shovels through the manhole, and the still is re-charged every 24 hours. One stoker serves 8 to 10 stills, and a stillman attends to 14 to 16 stills. The stills are generally coked, but sometimes the distillation is stopped and the residue run off to coking stills; this adds to the life of the stills. With vacuum distillation the suction is gradually increased from a slight vacuum at the beginning to 16—20 inches of mercury when the heavy oil and paraffin come over. Three-fourths of the charge is distilled off in 6 or 7 hours, the residue is cooled for $1\frac{1}{2}$ hours and then run off to the coking still. The principal still gets 15 to 16 charges per week. Vacuum distillation saves fuel and has many advantages. The plant is kept fully occupied. Ten stills are charged at once in 10 minutes, hastened by the suction of the vacuum plant. The receivers are sometimes of cement, but now generally of iron.

Continuous distillation has only lately come into use. Wernecke in 1907 introduced a new type of continuous still. It is of circular cross-section, conical, broad at the top, narrow below. There is a series of flat rings fixed to the side of the still at such an angle as to form a series of gutters or channels. The oil flows from channel to channel down the stairs, distilling all the time, thus constituting a continuous operation. The residue runs off. The vapor exit at top carries off the light vapors to a condenser, while a pipe rising from the center of the bottom carries off the heavy vapors to another condenser. The oil vapors never touch the heated walls of the still and so do not crack, and the oil surface is twice that of the heating surface. The still only requires cleaning once in 6 or 8 weeks, and then the rings are easily lifted; there is little coking. A vacuum of at least 720 mm. is used (28 inches). The vacuum reduced the fuel consumption by 25%. There is a preliminary feed heater with a furnace for itself; and the temperature is shown by two thermometers, and ranges from 100°—210° C. There are three thermometers in the still. Towards the top the temperature is 230°—240° C., and towards the bottom 260°—280° C. The still produces an oil of high viscosity. The greater the vacuum, however, the less crystalline is the paraffin. The charge of oil is 600 kilos, (150 gallons), and 1,500,750 kilos, (380,000 gallons) is distilled in 826 hours.

The still benches are in all cases protected by walls, and roofed over with corrugated iron or felt. The stillman's platform has a fireproof partition protecting it from the fireman's platform.

The crude oil stills if distilled to dryness at ordinary pressure last 6 or 8 months; vacuum stills 6 to 8 years.

The ordinary specific gravity of Saxon crude oil is 0.870—0.880. By the first distillation it is fractionated into: 33% light oil, sp.gr. about 0.870, boiling range 100°—350° C.; 60% paraffin mass, 2% red grease, used for grease-making; 1% red product, returned to the crude oil; 2% coke; 2% permanent gas.

The light oil chemically treated and distilled produces a light oil and an intermediate oil containing soft paraffin. This light oil treated and distilled produces the marketable products benzine and solar oil. The benzine has sp.gr. 0.790 to 0.810 and flash point 25°—35° C. It has a faintly yellow color with blue fluorescence and is used mostly for refining the paraffin. The bulk of it boils below 200° C. The solar oil, sp.gr. 0.825 to 0.835, has a light brown color; flash point 45°—50° C. It boils below 270° C. Formerly used solely for lamps, it is now used for oil-engines.

If the crude oil has not been treated with chemicals before distillation, the paraffin mass (the heavy oil containing paraffin) is now treated before cooling and pressing. The expressed oil is sometimes treated before distilling again, sometimes not. In distillation the oil is not coked, but 5% of the residue is run off without distillation, and sold as goudron. In the after distillations there are great variations in the different works and in the same works at different times, depending on the requirements of the market.

The heavier oil products are:

Pale vaseline oil, a general name for cleaning oil, 0.848—0.850, having a pale yellow color; yellow oil, 0.860—0.870, which is straw yellow; and red oil, 0.870—0.880. The yellow and red oils are mostly used for gas-making.

Dark vaseline oil, or *gas oil*, 0.880—0.890. Red-brown, used mostly for lighting railway carriages with incandescence burners; also for carburetting water-gas. It is extensively used for Diesel motors.

Heavy vaseline oil, 0.905—0.920. Dark brown, used for same purposes as dark vaseline oil, also as liquid fuel for the Navy; for the last-named purpose it is atomized by steam jet.

Fat oil, also 0.905—0.920. Red or brown. Sold unwashed; or refined for lubricating oil mixtures, when it is yellow.

Chemical treatments.—When the crude oil is treated before distillation the sulphuric acid used is of sp.gr. 1.53 or 106° Tw. In the other treatments the acid is sp.gr. 1.84 or 168° Tw. Fuming acid has been tried but does not give satisfactory results.

The caustic soda solution is made by dissolving drum soda in water, and is used of sp.gr. 1.36 to 1.38, or 73° to 76° Tw.

Some impurities in the oil are separated as tar with either sulphuric acid or caustic soda, whichever is used first, and sulphuric acid being the cheaper is in general applied first, unless there is a demand for creosote, when the soda is used first. To use the soda first has this advantage that the products of the soda reaction are more easily washed out than the products of the acid reaction, so that secondary reactions are more easily avoided in subsequent distillations.

After the sulphuric acid treatments, settling and running off the tars, the oil is washed with water once or twice, then with recovered or weak caustic soda, and finally with strong caustic soda solution. The acid and soda washings are done in the same vessel, except for the finishing treatment. Creosote left in the oil causes the retention of solid paraffin.

The washers have capacities of 1,100 to 4,400 gallons. (In Scotland 30,000 to 40,000 gallons is washed at once.) Formerly the washers were of wood, now all are of lead-lined iron, the lead being 1/5 inch thick or so. The washers are always housed with sometimes a pipe to carry off the sulphur dioxide and other gases into the open air. The agitation long ago was effected by wooden paddles worked by hand; afterwards mechanical stirrers were used; in recent years it is by air-stirring. The washers are vertical cylinders with conical bottom, and the air is led down to the center of the bottom by a lead pipe. (In Scotland it is the custom to use malleable iron washers without lead lining, the strong sulphuric acid scarcely acting on the iron.) Oil containing paraffin is kept liquid for treatment by steam coil or steam jacket.

Whether the crude oil should be treated before distillation or not is a matter on which authorities differ. Treating first has certain advantages. There is less noxious gas on distillation, the coke is 50% less, and there is less permanent gas. Less heat is needed on the stills, and the stills last longer. With certain crude oils the yield of paraffin is increased by the preliminary treatment; with others it is decreased. It may be that when bitumen is present as such in the crude oil it comes down with the vitriol tar, and bitumen is capable of producing solid paraffin by destructive distillation, and is thus lost. Certain authorities hold that the retorting can be manipulated so that all the bitumen is decomposed and that if this is managed the preliminary acid treatment does only good. (In Scotland it is found that destructive distillation of the crude oil is best; if acid is given first the total loss on refining is increased. The still-coke is valuable, and it is wanted free from chemicals.)

When the paraffin mass has to be treated before cooling and pressing, it has to be very thoroughly washed with water after the soda treatment.

In treating the crude oil, to free it from water, $\frac{1}{4}$% of 106° Tw. acid is stirred in, or 1 to 2% of recovered acid. After this has settled and the tar run off, 3 or 4% of 168° Tw. acid is stirred in for $\frac{1}{4}$ hour. After settling for 3 or 4 hours and running off the tar, hot water is sprayed over the surface and milk of lime stirred in for $\frac{1}{4}$ hour. After settling and running off the tar the oil is ready for distillation. At this stage there is a great tendency for the oil to emulsify, and to prevent it skill and care are required.

In the subsequent treatments the lightest oils get 1—2% of acid, the heavier ones 2 to 4%, the hard paraffin mass 3 to 6%.

For the finishing treatments the acid and soda have separate washers. Only the paler oils get a finishing treatment at all, and this only in a few works. If found necessary to give a finishing treatment to the heavier oils, 1 to 3% of sulphuric acid is used, then weak caustic soda, sodium carbonate, or sodium silicate. Sodium silicate is very useful for pale heavy oils. In refining, a total of 6 to 7% of sulphuric acid is used and 0.8 to 1.3% of caustic soda, calculated on the crude oil.

The refined oils are settled in iron tanks, holding 10 to 30 tons, until the water settles out and the oil becomes bright. For heavy oils a close steam coil is fixed at the bottom of the tank. Storage tanks, generally cylindrical, used to consist of pits of concrete or brick faced with cement; now they are generally of iron, embedded in a bricked pit, or on sand with a layer of asphalt. There is great variation in size, the largest being 770,000 gallons.

All the oils used to be sent to market in barrels, and in very early times in glass carboys. Now 75% or so is delivered by railway tank wagons.

Solid paraffin separation and refining.—Exhaustive attempts have been made on a works scale to extract the solid paraffin direct from the crude oil without distillation. The scale turned out dark and difficult to refine, and the method was abandoned. Paraffin is insoluble in alcohol, while the oil, resin and creosote are soluble, but no practical man thinks of trying this on a works scale, although the method has been patented.

The distilled paraffin mass has been experimented on, to try to separate the paraffin by other means than cooling and crystallizing, but as yet without success. Certain gases have been tried. Krey proved that the separation could not be carried out by dialysis. Centrifuging has not yet been successful.

In Saxony the paraffin mass is cooled in vessels, holding 6 to 12 gallons, with sides either vertical or tapered towards the bottom. They are exposed in cellars, first to air-cooling, then to water that has been used and is somewhat warm, then to cold water from spring or mine, so that by gradual cooling good crystals should form and grow. The cooling takes 4 to 6 days. Occasionally larger vessels of 22 gallons are used, and cooled only by air in airy apartments. This takes 10 to 15 days. The hard paraffin mass is cooled to 15° to 18° C. by natural cold in this way, and no refrigeration is used.

The soft paraffin masses are in some works crystallized in tanks of 500 to 1,100 gallons capacity by the natural cold of winter, and the product is stored until winter comes and is then worked up. This requires a storage of about 1/3 the annual crude oil throughput. The cooling tanks are housed in buildings of light construction, and with walls that can be manipulated like venetian blinds, so as to let in the cold or keep out the heat as required.

In other works refrigerating machinery is used for the soft paraffin mass, which is put into small vessels, and cooled first with water, and then with cold brine. Ammonia solution machines were first adopted and the cold carried to the oil by a brine; but compression ammonia machines are now preferred as more efficient. The mass is cooled to —10° C. Refrigerating is much more efficient than natural cooling, and is carried on all the year round with many advantages. Wernecke uses cooling cells in a brine tank, and when the mass is firm

*From a paper read before the Edinburgh Section of the Society of Chemical Industry, and published in the Journal of the Society

it is ejected by pneumatic pressure into a conveyor to take it to the filter-presses. It is considered that for smaller works up to 5,000 to 6,000 tons a year natural cooling is most suitable; but for larger works refrigerating machines are certainly better. When natural cold is used and the paraffin crystallized, the oil can be drawn away from the paraffin without the use of filter-presses. Otherwise filter-presses are used first and hydraulic plate-pressing after. Plate-pressing without the filter-pressing was tried but would not do.

The chillled paraffin masses are pulped in a mechanical crusher, pumped from the receptacle below, and delivered to the filter-presses. The paraffin is scraped from the cloth of the filter-press with wooden spades. One filling of the filter-press yields about 1½ cwt. of scale, containing still some 26 to 30% of oil, and this is taken out with vertical plate-presses as in Scotland. The pressure is 100—150 atmos. The plate-press cloths are 32 to 38 inches square and the best are of wool on the inner side and linen outside, folded to a square of 15 to 22 inches; they are superposed in the press and covered with plates of sheet iron slightly warmed. 1½ cwt. of scale from a filter-press yields 120 lb. of pressed scale. Referring to the diagram of operations given above:

"A" mass yields 15—20% of paraffin, m.pt. 50—55° C.
"B" mass yields 10—15% of paraffin, m.pt. 40—45° C.
"C" mass yields 10—15% of paraffin, m.pt. 38—42° C.
Solar mass yields 15—20% of paraffin, m.pt. 35—40° C.

Attempts have been made to refine paraffin with sulphuric acid, as in ozokerite refining, also with chlorine, sodium sulphide, etc.; but all methods have given way to washing with brown coal light oil, called benzine, although it is too heavy and of too high a flash point to be included among the "spirits." Brown coal scale is always dark in color. The sweating process used in Scotland and elsewhere does not serve the purpose; the amount of impurity is too great and the color too persistent. Plate-pressed scale still retains 10—15% of oil. The paraffin is melted, mixed with benzine, and run off on to the surface of water. It solidifies into a homogeneous mass. The cake, 1 inch thick, is cut into squares and pressed in a horizontal hydraulic press. The presses hold 30—60 cloths, and a pressure of 200—250 atmos. is used. Two pressings are given, sometimes three, using lighter benzine each time. The presses are seldom heated with steam-pipes. The smell of benzine is removed by currents of steam passed through the melted wax, sometimes in stills, sometimes in open vessels; and if a still is used vacuum may be caused by a Koerting injector on the condenser. The steaming is continued for 30 to 48 hours. The temperature of the steam is kept at 130° to 140° C. and must not be over 140° C. The steam must therefore not be highly superheated or at more than 4 atmos. pressure. This treatment makes hard paraffin odorless, but soft paraffin retains some smell. The color of the wax is a faint greenish yellow. Bone-black was formerly used for a finishing treatment; latterly, char from ferrocyanide making has been employed. Clay, fullers' earth, and vegetable charcoal have also been tried. Before use the powder is dried at 100°—110° C., in ovens of various kinds derived from other industries. From 1 to 2% of char is used. No advantage is found from using more than this quantity, but it is sometimes given in two quantities. It is found inadvisable to use air in stirring. The product is thoroughly mixed for ½ hour by mechanical or hand-operated stirrers, at a temperature of 70°—80° C. The mixture is allowed to settle and the wax filtered through paper in filter-presses. The paraffin is extracted from the used char by benzine in apparatus that differs in every works. The char cannot be regenerated by calcination. Each works tests for itself the decolorizing powder most suitable in its own case. A mixture of pure carbon and silicates is good.

Other liquids have been tried in place of benzine. Oleine, amyl alcohol, and other alcohols have been tried but found impracticable and expensive. Amyl alcohol has a strong smell and produces headache. The use of carbon disulphide involves high fire risk. Pyridine bases produce a fine white wax which is rendered inodorous by sulphuric acid of 1.26 sp.gr. (52° Tw.); this reagent is cheap enough but its penetrating disagreeable odor renders it inapplicable.

The paraffin wax varies in m.pt. from 35° to 62° C. When it melts below 50° C., it is called soft wax, above this it is called hard wax. It flashes at 160°—185° C. The sp.gr. of paraffin of m.pt. 20° C. is 0.883; m.pt. 45° C., 0.908; m.pt. 58° C., 0.915. The hard wax is used principally for candles. There are five paraffin candle works in Saxony turning out 8,000 tons of paraffin and composite candles per annum. The m.pt. of the candles is 125°—130° F. (50°—55° C.).

Soft wax, m.pt. 35°—40° C., is largely used for dipping the sticks of matches; 1,000 tons per annum is used for that purpose.

Messel refining.—At Messel the sp.gr. of the crude oil is 0.855 to 0.860. On distillation it yields: Spirit, 4.00%, gas oil, 63.00%, and crude paraffin, 7.50%, while gas, coke, and loss in refining amount to 25.50%.

The crude oil is settled and without chemical treatment is pumped into high-level charging tanks from which the oil is run to the stills as required. The stills are much larger than in Saxony, and hold 1,600 to 1,700 gallons. Partial vacuum is applied, and there are stirrers in the stills, which are worked continuously. The heavy residue is run off and coked in separate stills. There are mercury gauges to show the vacuum. The fuels used are the tars extracted from the vitriol and soda tars. The crude oil distillate is 16% light oil and 76% of a heavy fraction. The light oil is treated with 2% sulphuric acid and 3% caustic soda solution, and on distillation yields spirit, lamp oil, and gas oil. The heavy fraction receives a similar treatment and on distillation yields some light oil and the bulk as paraffin mass. The mass is air- and water-cooled to 15° C. and pressed, giving a hard paraffin. The oil filtrate is cooled down to —2° C. by cold brine from a freezing machine and pressed again, giving a soft paraffin. The oil is used for gas oil. The lamp oil is treated and has a good color and smell, sp.gr. 0.800; but for burning in lamps it cannot compete with petroleum. The plant for cooling the paraffin occupies only one-tenth the space of a Saxon cooling plant. The vessels for the first cooling are vertical cylinders with scrapers which disturb the mass little but let new oil forward to the cold wall, and send the solid towards the center. The oil is much more viscous than in Saxony. The second cooling of the oil filtered from the hard scale is carried out in large jacketed cooling tanks, with horizontal scrapers working at a slow speed. When chilled sufficiently the mass is pumped to the filter-presses without requiring further breaking up. The scale from the filter-presses is plate-pressed in vertical hydraulic presses. The Messel paraffin can be sweated to quality equal to American semi-refined for the market; or it may be further refined with benzine. For double refining it is first treated with small quantities of acid and soda, distilled in vacuum, and then refined as usual. The products are spirit, sp.gr. 0.800, used extensively for petroleum engines; cleaning oil, 0.825 to 0.835; fat oil, 0.860; and lubricating oil, 0.890—0.892, usd for light machinery. There are small quantities of other products.

Full details of Messel working are not given.

In Scotland the sulphuric acid is used twice over in the refinery, first for the finishing treatment of the oils and then for the first treatment. The acid is separated from the vitriol tar with hot water, saturated with ammonia, evaporated in vacuum apparatus, and the sulphate of ammonia centrifuged. In Saxony they do not recover the ammonia. They wash out the acid as we do, but a proper use for it is still sought. Some of it is used for setting free the creosote from the soda tar, and some goes to the manure manufacturers. It cannot readily be purified or concentrated.

The recovery of purified nitrogenous bases has been successfully carried out in several works. The pyridine bases were used for purification of anthracene, and for denaturing spirit to suit the German law of 1887. Now, however, the denaturing law is more stringent and this use has been given up. There is little pyridine present, the series beginning in quantity with the picolines. Lutidines are present, but bases of higher boiling point present in larger quantities have not even been isolated.

The vitriol tar neutralized with soda tar is distilled and the residue is a glossy black solid, sold as asphalt. The goudron, the residue of the heavy oil not coked, is black and has the consistency of dough.

In the brown coal oil factories the chemists analyze the coal and select the material suitable for retorting, and see that it is properly distilled. They test the intermediate and finished products. They analyze and advise on the chemicals to be bought. The problem is always before them of improving the marketable products and at the same time cheapening the refining.

In regard to the coal testing, after careful sampling, which is always the most important part of an analysis, the moisture and ash are determined, the result of dry distillation noted, and the calorific value and percentage of bitumen determined. In determining the moisture it must be remembered that the coal readily absorbs oxygen and gives off carbon dioxide; so it is carried out in a current of inert gas or *in vacuo*. The laboratory distillation is carried out in a glass retort, fixed to a glass receiver by a cork which has also a tube to carry off the gas evolved; 20 to 50 grms. of the retort coal in its natural moist state is used. The heat is applied gradually, kept an hour at full heat, and the temperature then gradually lowered. It takes from 4 to 6 hours. The retort is weighed empty, charged, and after the distillation; and the receiver before and after use. The receiver is heated to cause a thorough separation of the oil from the water, then chilled with cold water or ice, and the cake of solid crude oil taken out, dried with filter paper and weighed. The oil yield in the works is only 60% of the laboratory yield.

The bitumen is determined in dried coal with benzine in a Soxhlet apparatus. The bitumen extracted is a brittle solid melting at 80°—85° C., and is extensively used for phonograph cylinders and stove polishes.

Crude oil contains 10 to 15% of solid paraffin. In the products of distillation the paraffin series is present from C_1 to C_{38} or more, also olefines, acetylenes, and other hydrocarbons. In the crude oil the following substances are present according to Erdmann as quoted by Scheithauer:—Paraffin series: Heptane, normal monane, normal decane, undecane, heptadecane, octadecane, nonadecane, eicosane, heneicosane, docosane, tricosane. Ethylenes: Decylene. Aromatic hydrocarbons: Benzene toluene, *m*-xylene, mesitylene, naphthalene, chrysene, picene, and a hydrocarbon, $C_{16}H_{18}$, m.pt. 117° C., b.pt. 300°—302° C. Naphthenes, in small quantity. Bases: Pyridine, -picoline, -picoline, -picoline, 2.6-dimethylpyridine (lutidine), 3.4-dimethylpyridine, 2.4-dimethylpyridine, 2.5-dimethylpyridine, 2.4.7--trimethylpyridine (collidine), quinoline, aniline, and a nitrile. Oxygen compounds: Homologues of acetone, phenol, *o*-cresol, *m*-cresol, *p*-cresol, guaiacol, creosol. Sulphur compounds: Carbon disulphide, thiophene.

My principal authorities for the foregoing notes are:—*Die Braunkohlenteer-Industrie*, by Dr. Ed. Graefe, 1906. *Die Braunkohlenteerprodukte und das Oelgas*, by Dr. W. Scheithauer, 1907. *Die Schwelteere, Ihre Gewinnung und Verarbeitung*, by Dr. W. Scheithauer, 1911. Of this last book there is a translation into English by Charles Salter, "Shale Oil and Tars" (Scott, Greenwood & Son).

A Soldered Molybdenite Detector

In 1911 L. W. Austin described a thermocouple, useful also as rectifier for high-frequency currents, consisting of a piece of tellurium and a platinum wire. Experimenting on similar lines, Professor C. Bergholm, of the University of Upsla, Sweden, found that molybdenite and quartz gave a very much more sensitive combination when soldered together by means of a platinum wire bent to a U, but that different spots of a molybdenite crystal behaved differently, and that it was necessary first to find the suitable spots of the crystals, which are scaly like graphite. In the *Annalen der Physik* of February 15, 1917 (vol. lii, page 102), Bergholm explains how he makes his detector or rectifier. The base of the instrument is a stout disk of ebonite, into which four holes are drilled. Two of the holes are horizontal in the direction of a diameter of the disk, two vertical; copper wires or rods are so fitted into the holes that they form the arms of two right angles, the horizontal arms serving as terminals, the vertical rods as supports. One of these vertical rods bears a cup of sheet copper, partly filled with Lipowitz alloy (of low melting-point); the crystal of molybdenite is embedded in enough of this alloy to be held firmly. A quartz crystal is not mentioned, and apparently the detector consists essentially only of molybdenite and platinum, the junction being effected with the aid of a bent platinum wire, extending from the cup and crystal over to the other copper rod. The first point is to find the suitable spot of the molybdenite crystal. For this purpose a rather thick platinum wire, 0.3 mm. in diameter, is first soldered to the copper rod not supporting a cup, and the free end of this wire is successively pressed against different spots of the molybdenite, while the detector is inserted in an electric circuit provided with a commutator. When certain spots of the crystal are touched, it will be observed, no current will flow; at others the current will pass in either direction; at others, again, the current will only flow in one direction. These latter unipolar points are the suitable points. The stout platinum wire is then replaced by a fine platinum wire, 0.02 mm. in diameter, which is soldered to the spot of unipolar current flow. This wire must be thin, lest the elasticity of the wire weaken the soldered joint. To facilitate the soldering a little gold is, by cathode volatilization, deposited on the crystal.—*Engineering.*

Inadequacy and Inconsistency of Some Common Chemical Terms*

By Carl Hering

The fact that our grandfathers did things in a certain way, and that this way was good enough for them, is not always a safe reason for our doing so today, although when stated in different terms this reason is often accepted today by some as safe and sufficient. Physical chemistry has done so much lately for the advancement of chemistry that its dictates should receive respectful consideration.

The purpose of the present article is to point out the looseness, inconsistency and inadequacy of some common conceptions, terms, and expressions, in chemistry, and to suggest reforms

Valence.—The term valence, meaning the number of bonds which unite the elements, or the number of atoms of different elements which combine into a molecule, has been used rather loosely, causing confusion and inconsistencies. It would avoid confusion and be more clear and precise, if the term "valency" were used to express the general *property* of an atom of that element to combine with other atoms in various proportions, while the term "valence" should then be limited to the *one particular value* in any one specific case. Thus it should be said that copper as an element possesses the property of having a *valency* of 1 and 2, and that in cuprous chloride it has a *valence* of 1 and in cupric chloride a *valence* of 2. This reform has already been suggested by others and should be encouraged.

Different kinds of bonds.—In what are known as structural formulas, some of the bonds are sometimes supposed to combine atoms of the *same* element. Thus in H_2O_2 one of the two bonds of O is supposed to unite the two atoms of O with each other. The modern and probably generally accepted theory of chemical reactions, at least in cases of electrolysis, shows that every one of the bonds between different elements (for a mono-valent gram atom) which is destroyed or created by the current involves an electric charge of one faraday (96,500 coulombs or 26.80 ampere-hours); this is true for all the elements, at least in electrolysis; the ions carry these charges from one electrode to the other; this is the basis of the generally accepted Faraday's law. To separate from each other two or more atoms of the *same* element by electrolysis, which would imply setting free the same element at both electrodes, is apparently not possible, and if this is true it must follow that those bonds which are supposed to unite atoms of the same element, if they exist, must be physically of a different nature, and should therefore be distinguished in some way or by some term from the other kind which are well known to exist and are universally recognized. In what follows the only kind of bonds referred to are those which unite different elements, and the term valence is here used as referring only to those.

Negative valences.—Most of the elements will, in electrolysis, always go to one particular electrode and never to the other; hydrogen, for instance, always goes to the cathode and oxygen always to the anode. According to the modern accepted theories, hydrogen atoms always carry positive charges of electricity and the oxygen atoms always carry negative charges. This alone should be a sufficient reason to give the valences distinguishing signs, and therefore to say that the valence of hydrogen is +1 and that of oxygen—2, hence to use negative valences, as was suggested many years ago (see the writer's article in *Metallurgical and Chemical Engineering*, January, 1903, p. 169).

But there is another and even more important reason for doing so. Some of the elements, namely, antimony, arsenic, bromine, carbon, chlorine, iodine, nitrogen, phosphorus, selenium, silicon, sulfur and tellurium, seem to act sometimes like hydrogen in this respect, and at other times like oxygen; or according to modern theories they sometimes carry negative and sometimes positive charges, hence it is inconsistent not to distinguish between these different states as is easily done by giving the particular valence a sign; that is, by stating whether on any particular combination the valence is positive or negative.

As an illustration of the utility of this conception of negative valences, the S in H_2S must be considered to have a valence of—2, while in SO_3 it must be considered as having a valence of +6. Hence to change the former into the latter involves a change of valence of—8 (the algebraic difference) and electrochemically this means 8 faradays and not 4, which would be the numerical difference if the negative sign be omitted; the sign of the difference 8 designates the direction of the current which would produce this result. Another illustration is the "oxidation" of methane CH_4 (more consistently written H_4C) into carbon tetrachloride CCl_4. In the former the carbon should be stated as having a valence of—4 and in the latter +4, hence the change of valence involved is —8 and not zero, as would follow if the signs are omitted.

Change of valence.—All electrolytic reactions must be considered broadly as involving a *change* of valence, no other kind seems to be known, and the quantitative calculations are based on this change. The oxidation of ferrous into ferric sulfate, for instance, involves a change of valence of 1 in the iron. The setting free of oxygen from water is depriving it of all of its 2 bonds, hence is a change of valence of 2. Some quantitative electrochemical calculations are greatly simplified by basing them on this change of valence, as every unit valence of such change requires 26.80 ampere-hours for each monovalent gram atom of the elements.

Zero valence.—By a zero valence chemists usually mean that the element never combines with others, which is the case for instance with the noble gases like argon, etc. This is not consistent because any element in its free and uncombined state necessarily has no bonds connecting it with other elements, hence when in that state it must be considered as having a zero valence. Reducing the metals or the gaseous elements to their free state by electrolysis, means changing their valence from what they had in the combination, to zero. An in those elements which have both +and—valences, the change from one to the other necessarily involves passing through zero, which is their free state. A consistent way of stating these facts would be to say that the *valency* (a property) of the noble gases is zero, and that the *valence* (a specific value) of all the elements, is zero in their free state. Or it may be said that elements like argon are non-valent.

Reduction.—All chemical reductions, when interpreted according to modern accepted theories, mean a reduction of the valence, whether from + to or toward O or from O to—or from + to—. Broadly therefore, it is physically the same process to set free hydrogen from water, a reduction from +1 to 0, as it is to combine free oxygen with some element as far as the oxygen is concerned; that element is properly said to be oxidized, but the oxygen must be said to be reduced, as its valence (and therefore its oxidizing property) has thereby been reduced from 0 to—2. Chemists will not like to apply the term reduction to this change in the oxygen, yet as it is physically exactly the same process and in the same direction as setting free combined hydrogen or a metal, it necessarily must be placed in the same class, and if it is not palatable to the chemist to embrace this under "reduction," then a new term should be coined for covering this physical process more broadly.

Oxidation.—Similarly with the chemical term oxidation, though in this case the term is even worse as it implies a combination with oxygen, yet it is today by general consent (though inconsistently) extended to include combinations with other elements also; $Cu + Cl = CuCl$ is called oxidation.

Setting aside the views of our grandfathers, what this word is really intended to mean in its broad sense is the physical opposite or verse of reduction, hence the same process in kind but different only in direction; according to modern theories therefore it means broadly an increase in valence, from—to or toward 0, or 0 to +, or—to +, and of course this is independent of whether oxygen itself is involved or not. To combine a free element with oxygen, fluorine, etc., is to increase its valence from 0 to +, which process is today called oxidation of the element (not of the oxygen). But it is physically exactly the same process as to increase the valence from—to 0, as for instance in setting free sulfur from H_2S, in which case the change of valence of S has been from —2 to 0. It is necessarily also exactly the same physical process as in setting free oxygen from an oxide, as the valence of the oxygen has thereby been increased from —2 to 0; to call this "oxidizing the oxygen" would probably not be palatable to the chemists, yet that is what it really is when considered broadly as a physical process; this inconsistency however, is lessened by the fact that such oxidized oxygen (free oxygen) is a stronger oxidizing agent than combined oxygen, just as reduced hydrogen (that is, free) is a stronger reducing agent than combined hydrogen.

A term is therefore needed for expressing this physical process, namely the exact reversal of chemical reduction (a reduction in valence), and meaning broadly an increase of valence from—to or toward +. Many years ago Prof. J. W. Richards suggested the term "perduction" (which the present writer used in this journal, January, 1903, pp. 172 and 174); the objection to it is that the chemists already used the prefix per- in the sense of super-, hence it gives rise to confusion. Numerous other terms have been suggested, like preduction, induction, etc., but the best one seems to be "adduction," suggested recently by Dr. Frederick H. Getman, as the prefix implies an addition, hence the sense of increasing or adding to the valence.

In the opinion of the writer the words "adduction" (for oxidation) and "reduction" are satisfactory terms to use, for these two identical though opposite or reversed physical processes, as it merely involves overcoming unreasonable prejudices against extending the old and well known term reduction to embrace broadly all cases of reduction of valences, and as this would not involve the inconsistency that was involved in applying the word "oxidation" to other elements than oxygen, there ought to be no difficulties in doing so.

*From *Metallurgical and Chemical Engineering.*

Nature of Coronium Atom

It has already been pointed out in the electronic theory of series spectra that certain lines in the spectrum of the solar corona showed constant differences between their cube roots. At the last solar eclipse of Aug. 21, 1914, Deslandres and Carrasco found a new line in the red, at $\lambda 6374.5$, and it is interesting to find that this line also fits in exactly with the cube-root relation. Two other lines, $\lambda 4566.0$ and $\lambda 3642.5$, are then shown to be included in a related series, and an analysis is given showing that coronium is probably due to the simple ring system with nucleus $7e$ and 8 electrons forming altogether a single negative charge.—J. W. Nicholson, *Royal Astronomical Society*, M. N.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, OCTOBER 27, 1917

Published weekly by Munn & Company, incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) 4.00
The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check.

Munn & Co., Inc., 233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Back Numbers of the Scientific American Supplement

Supplements bearing a date earlier than January 1st, 1916, can be supplied by the H. W. Wilson Company, 39 Mamaroneck Avenue, White Plains, N. Y. Please order such back numbers from the Wilson Company. Supplements for January 1st, 1916, and subsequent issues can be supplied at 10 cents each by Munn & Co., Inc., 233 Broadway, New York.

Table of Contents

27, 1917

tory terms
or reversed
overcoming
he old and
ly all cases
not involve
g the word
here ought

electronic
e spectrum
es between
f Aug. 21,
line in the
l that this
tion. Two
own to be
is is given
he simple-
s forming
NICHILSON,

CAN

7, 1917
porated
erse Beach

Class Matter

s
r year $5.00
. . 4.00
n countries
ation.
or check.
ew York

publish
distin-
ant arti-
ons, and
thought
orld.

erican

January
son Com-
s, N. Y.
son Com-
nd subse-
by Munn

e are in a
y branch
composed
ts, ther-
atent ap-
e of the
echnical,

rld, who
mark ap-
e United

o.,
tors,
dway,
k, N. Y.